Evaluation study of Biomass Gasifier Systems at Haryana

Submitted to

Haryana State Energy Development Agency
SCO 48, Sector 26
Chandigarh 160 019

By

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Director

January 6, 1999

Mr Keshub Mahindra
Chairman
Mahindra & Mahindra
Gateway Building
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Mumbai 400,039

Dear Mr Mahindra,

In keeping with the new challenge posed by the enactment of the Electricity Regulatory Commission Act, 1998, the Tata Energy Research Institute (TERI) established a Centre for Regulatory Studies (CRS), which is acting as facilitator for making the new regulatory environment more effective and meaningful. The activities of the CRS include research, advice to regulatory commissions on issues of better governance, dissemination, training programme/seminar on regulatory issues etc.

As a part of its activities, a national conference on *"Transition to a liberalized environment: experiences and issues in Regulation"* is being organised during February 3-4, 1999 in New Delhi in association with the Infrastructure Development Finance Company Limited (IDFC). The conference is also supported by the Central Electricity Regulatory Commission (CERC) This event will be the first of its kind to bring together the key infrastructure sectors: Power; Oil & Gas; Ports; and Telecom and provide a platform to share current experiences and concerns of regulation in India.

Being the first of its kind and to enable larger participation the delegate fee for the conference has been kept very low and hence the Conference invites Corporate Sponsorships from organisations. The conference extends several levels of sponsorship opportunities and the details of the same are in the enclosed 3-page sponsorship brief.

We request your esteemed organisation to join us in organising this unique conference as a Sponsor. Several senior representatives from the Central and State Regulatory Authorities and more than 200 senior executives from the infrastructure sectors are expected to attend the event. We require a confirmation from you on or before **22 January, 1999** to enable us to incorporate your company's name in all our publicity material.

I would be happy to provide any further details or clarifications if required.

Yours sincerely,

(R K Pachauri)

encl: as above.

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1. Introduction

1.1 Preamble

Biomass Utilization through gasification was recognized as an important renewable source of energy for the country in the mid-seventies. To move from this condition to one in which, research groups, manufacturers, and nodal agencies to act as interface between government, users and other agencies, work in some degree of cohesion with appropriate information transfer and mutual support has taken a fair amount of effort. Among many who contributed to this effort the major drive came from the biomass gasification section of the then Department of Non-conventional Energy Sources (DNES) (now Ministry of Non-conventional Energy Sources, MNES) which had taken innovative managerial approaches to progress the field for the benefit of the country.

1.2 The early experience

The groups which were studying biomass utilization in a serious way in the late seventies and early eighties were IIT, Delhi for conversion into char to be used in stoves, M/s Jyoti Ltd., Baroda and Sardar Patel Renewable Energy Research Institute (SPRERI), V V Nagar, on gasification. The Nimbkar Agricultural Research Institute (NARI) at Phaltan and Punjab Agricultural University (PAU) at Ludhiana were also involved in work on biomass gasification. A little while later Indian Institute of Science, Bangalore also started working on gasification. Tata Energy Research Institute (TERI), Delhi got involved in this area in early eighties. The major emphasis was to identify problems and to find technological solutions for the same to make the gasification technology reliable and user friendly for proper dissemination and utilization.

A little later, a few technologies from M/s Ankur Ltd., Baroda, Indian Institute of Science, Bangalore and SPRERI, Baroda, V V Nagar were claimed to be made available for possible tests and trials in the country. A few major projects concerning test facilities as IIT, Bombay for evaluating the gasifier engine systems, had been sanctioned and these facilities were being built up. It is in this set of circumstances that actions were to be initiated towards a new programme on gasification. At the initiation of the program it was decided that indigenous systems based on the R&D

carried out in the country be encouraged and this has been maintained later all through.

One important point that became clear at the time when M/s Jyoti were producing the gasifiers and marketing them with the partial support of DNES is that, unless large orders are placed with fabricators/manufacturers, manufacturers would not be interested in participating in the programme which in the initial stage had to be largely promotional to generate confidence amongst a range of communities including users, consultants and administrators.

1.3 The Programme Elements

The Government of India (DNES), through a series of discussions with scientists, manufacturers, nodal agencies, proposed a single point responsibility for siting, supply, installation, training and warranty for two years. Since it was necessary to resolve questions about performance, life and related aspects it was decided to support research and development activities over several groups not limiting it to the then active groups. It was thought that some questions debated by researchers would not always get simply or adequately resolved satisfactorily by work with in the laboratories and it would be necessary to make field experiments on a larger scale. This meant identification and encouragement of the manufacturers. It was conceived that the responsibility for the entire range of services could be on the manufacturers as a part of bulk order of hundred on each of them. The three manufacturers, M/s M M Fabricators and Engineers, Bangalore (MMFE, Bangalore), M/s Ankur-Energy & Development Alternative, Baroda (Ankur, Baroda) and M/s Associated Engineering Works, Tanuku, (AEW, Tanuku) who responded to public advertisements on the subject were picked after considerable discussions on the technical capabilities and financial aspects. It was decided that these gasifiers should be tested at IIT, Bombay (where significant financial support by DNES was provided to create test facilities) so that the system should pass through a qualification procedure before being deployed to far-flung user sites.

A scheme for involving nodal agencies in different states to administer the programme was evolved. The nodal agencies were expected to be active in site identification, facilitate the subsidy distribution and do monitoring of the performance and support from the manufacturer so that the user can obtain the expected benefits.

In attempting to rationalize on the capacities of the various systems, it was found that the country had two to three million 5 hp diesel engine – water pump sets used in irrigation and therefore this became the first system to be considered for dual fuel operation, so that many farmers with small holdings can derive the benefits. Table 1 shows the systems, the elements and the subsidy pattern provided on each of them[1]. As can be noticed, in the first year, the subsidy was on the entire system. This was done to create awareness at the user end towards a new technology. This also helped in conducting the performance tests on the engine with a gasifier system. This was found particularly necessary because there were debates among scientists at that time on the performance of the systems. With better confidence in the system after a year of operation the subsidy element was reduced such that the user had to pay about 20% for obtaining the system package.

At the same time the confidence generated expanded the domain of end uses to be covered under the programme which included power generation and thermal applications. Over a period of time the subsidy component was further reduced and its scope was limited only to the gasifier and its components and not on the engine or pumps or on the gen set.

1.4 Rational behind this work

It was realized during the early stages of this programme that monitoring should be done at different stages as well as in several forms: by designers/manufacturers as well as by nodal agencies involving an independent organization. Some earlier efforts in this direction were found to be very useful and the recommendations of such monitoring exercises were incorporated in the programme. Besides the technology improvement inputs which such exercises have provided, one major contribution was the modified subsidy structure that was evolved during the later years taking into account the experiences of the previous years. Therefore, while the usefulness of such evaluations are well recognized the recent price increase of biomass in certain areas has put questions to the viability of biomass gasification and resulting lack of interest among users. In view of the above vis-à-vis the present technological improvements and programme components like the subsidy etc., the Haryana Renewable Energy Development Agency (HAREDA) wanted to evaluate the status of the installed gasifiers in the state of Haryana.

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[1] Singh, K.K., "Five Years of Indian Biomass Gasification Programme", Proc. of IV Nat Meet on Biomass Gasification and Combustion, Mysore, pp 8-20, 1993

Table 1: Programme on demonstrative application of biomass gasifier-engine systems [break-up of costs for putting systems into service (costs in 1000 rupees)] Ref.[1]

	Mode	5 hp	10 hp	2.5/3 kW	5/6 kW	10 kW	20 kW	40 kW	100 kW
1.1	Gasifier assembly + cleaning-cooling with accessories	16.0	20.5	18.0	30.0	50.0	105.0	180.0	350.0
1.2	Dual fuel engine + accessories	6.0	8.5	8.5	18.0	105.0	140.0	220.0	485.0
1.3	Pump set or alternator + accessories	3.0	5.0	16.0	35.0				
1.4	Set of spares	1.0	1.5	3.0	3.0	5.0	5.0	10.0	25.0
1.5	Set of tools	0.5	0.5	1.0	1.0	2.0	5.0	5.0	10.0
	Sub total	26.5	36.0	46.5	87.0	162.0	255.0	415.0	870.0
2.0	Erection + commissioning + mandatory run + training	2.5	4.0	3.5	8.0	13.0	30.0	40.0	80.0
3.0	G+W+S+Tax+duty+octroi*	1.0	2.0	2.0	5.0	15.0	15.0	25.0	60.0
4.0	P + F + T* Insurance (actual)	2.0	2.5	3.0	3.0	5.0	8.0	10.0	15.0
5.0	Implementation+management cost to agency	3.0	3.0	3.0	3.0	4.0	6.0	8.0	10.0
6.0	Civil works								
6.1	Foundation etc	1.0	1.5	2.0	2.0	3.0	6.0	8.0	15.0
7.0	Cost heads:								
7.1	Value (1+2+3)	30.0	42.0	52.0	100.0	190.0	300.0	480.0	1010.0
7.2	Implementation+management cost to agencies (4 + 5)	5.0	5.5	6.0	6.0	9.0	14.0	18.0	25.0
7.3	Civil works (6)	1.0	1.5	2.0	2.0	3.0	6.0	8.0	15.0
8.0	Implementation cost (each system)	36.0	49.0	60.0	108.0	202.0	320.0	506.0	1050.0

*(G,W,S,P,F and T indicate guarantee, warranty, servicing, packing, forwarding and transportation respectively)

This was done to decide the future course of action for the programme. With more than a decade of technical and field experience in the area of biomass gasification, TERI, was entrusted with this task.

1.5 Objectives

1) To evaluate the performance of biomass gasifier programme in the state of Haryana based on the 36 number of biomass gasifier systems installed between the year 1991-92 to 1995-96.
2) To assess the present status of functionality of these gasifiers which includes functionality rate; the reasons of non-functionality of the gasifiers; if gasifiers were used then, number of hours for which used, whether used in dual fuel mode or on 100% diesel, the problems encountered during the break down.
3) To assess whether adequate training was provided by the suppliers of the systems to the users in the maintenance, upkeep and operation of the systems.
4) To obtain detailed technical performance one gasifier system in each of the following categories to be tested, viz; 5kW, 10kW, 20kW, 40kW and 100kW [subject to the fact that they are in a condition that they can be tested]. The performance evaluation will include gas quality assessment by flaring the producer gas, measurement of flame temperature, flame stability, comparison of flame temperature and smoke level etc. The tar level of the cleaned gas to be assessed by examining the condition of the head, valves and gas intake manifold. In addition, one unit to be chosen for a detail testing which is to include testing of gas quality through Junker's gas calorimeter, quantitative analysis for tar and dust measurement in the gas, specific fuel consumption of gasifier genset unit and the diesel replacement achieved.
5) To assess the economic viability of this technology in Haryana in the present conditions with possible suggestions.
6) To suggest technological options for development of gasifiers which use wheat stalk, cotton stalk, arhar stalk, rice straw and rice husk as biomass feed materials, the economics of these technologies and the sources of availability.
7) Any other suggestions including suggestions from users for better managerial, training and operation and maintenance aspects.

The following chapters give details of the study to meet the above objectives. Chapter 2 describes the investigation methodology, the approach of the survey and the aims which were expected to be achieved as well as the rationale of the detailed testing of the chosen unit. The findings of the study have been elaborated in

Chapter 3 with a compilation of actual observations for all the units surveyed in a clusterwise approach and highlighting the major issues and trends as well as reasons for non use of the units. The Chapter 4 gives the details of the performance test and its results. The analysis and inference of this study can be found in Chapter 5 wherein each and every issue identified in Chapter 3 has been analyzed to draw conclusions. This chapter also gives a detailed economic analysis and the different reference indicators which should be considered to estimate a true economic viability of this technology in the local conditions. Chapter 6 contains a few recommendations and suggestions for a future course of action for the gasifier programme in Haryana.

2. Methodology

To carry out a study of this nature, it was decided to do the evaluation in 2 stages. In the first stage a user feedback was obtained in the form of their response to a questionnaire followed by an actual survey inspection of the installation by TERI professionals. During the inspection, notes were made to see whether the unit can at a later date, be operated and tested for the performance and to identify one unit which can be undertaken for detailed testing for all parameters. Under this methodology, therefore, the evaluation had two components namely the survey and the detailed testing.

2.1 Survey of the installations

For the survey a detailed questionnaire was made and sent to all concerned DRDA offices for forwarding them to the respective users and to have their feedback on the gasifier unit. This exercise was followed by a site inspection to gain the factual information. It was found in practice that taking user feedback was more appropriate during the inspection. The inspection therefore served both the purposes. A copy of the questionnaire and the inspection form used for this study are enclosed in Annexure - 1.

The questionnaire had been designed to have a complete feedback on the gasifier unit, such as exact location of the installation, followed by details about the unit, e.g.; model, capacity, make, type and kind of instruments provided, warranties etc. Information on some basic performance and maintenance parameters, application modes, were followed by detailed queries on usage of the unit. This section was added to estimate the total hours of operations, dual-fuel mode of operation, amount of diesel replacement achieved, technical problems faced if any, manpower requirement, mode of management of the unit by the user, training etc. The important aspect of biomass supply was also covered adequately considering points like type and kind of biomass, price, sourcing and availability of biomass, transportation cost, sizing and techniques for the same. Information also has been collected on financial aspects e.g. subsidy and a detailed impression of the user about the technology.

The inspection form also has a similar pattern. However, here the major emphasis is to identify the existence and the physical conditions of the major and peripheral parts of the installations. This is to make the assessment whether the unit was properly utilized and, if not, what were the causes for the same. During the inspection a preliminary effort was always made to actually test the unit if found feasible.

2.2 Detailed testing

For the detailed performance test, the original plan was to bring the identified unit to TERI's gasifier test facility at Gual Pahari. To this effect it was decided to inspect the 20kW power generation unit installed at Urja Gram, Rahuka, Gurgaon and if the system was found in good condition, to bring it to Gual Pahari. However, inspection revealed that not only the system was idle for many years but many important components of the engine, namely; nozzle, dial gauges, batteries, air filter etc. and the gasifier parts e.g.; pump, cutter motor, fabric filter were found missing. It was clear that the engine needed a major overhaul before any attempt is made for testing.

The focus therefore shifted on to another 40 kW unit at DFO, Pinjore, dist. Panchkula which was in a relatively better condition. While this was a relatively large unit, it was difficult to shift to Gual Pahari. Hence, it was decided to do the testing at field. Since the unit was not in operation for many years, major repairs was needed which included the electrical parts (motors, pumps), radiator of the engine etc.

A week long test was undertaken for this unit with cooperation of the user. The details of the same as well as all other units can be found in the next chapter alongwith the survey findings and results of this detail performance test.

3. STATUS OF THE EXISTING GASIFIER SYSTEMS IN HARYANA

The present chapter gives the compilation of gasifier site survey data obtained on the information collected from the responses to the questionnaire sent to the users as well as based on the actual site inspection by the study team professionals. As per the list provided by HAREDA [reproduced below as Table – 3.1] status of totally 36 units were to be evaluated.

Table 3.1: Gasifier Installations

Sl. No.	Name of the site	Capacity of system
1.	Chaudhary Surja Ram Cotton Ginning & Pressing Factory, Kalanwali, Sirsa	100 kW
2.	Forest Training Institute, Pinjore, Dist. Panchkula	40 kW
3.	Urja Gram, Haripur, Block Raipur Rani, Panchkula	20 kW
4.	RMS ceramics, Golpura, Block Raipur Rani, Panchkula	40 kW
5.	Oberoi Furniture House, Rai Market, Ambala Cantt	20 kW
6.	Gurukul Gharal, Jind	20 kW
7.	Gurukul Gendakhera, Jind	20 kW
8.	M/s. Rajan Steel, 38 Phase-I, Industrial Area, Yamuna Nagar	100 kW
9.	M/s. Rajan Steel, 38 Phase-I, Industrial Area, Yamuna Nagar	40 kW
10.	Haryana Industries, Khajuri Road, Yamuna Nagar	100 kW
11.	Forest Saw Mill, Forest Department, Yamunanagar	20 kW
12.	M/s. S S Engg. Corporation, 11 Industrial Area, Yamuna Nagar	20 kW
13.	Jamuna Engg Corporation, Harbanspura, Workshop Road, Near ITI, Yamuna Nagar	20 kW
14.	Haryana Agriculture University, Hisar	40 kW
15.	Urja Gram, Sandhlana, Hisar	5 HP
16.	88 Mechanised Birg, Hissar Cantt, Hissar (5 Nos.)	20 kW
17.	88 Mechanised Birg, Hissar Cantt, Hissar (3 Nos.)	5 kW
18.	88 Mechanised Birg, Hissar Cantt, Hissar (1 No.)	10 kW
19.	88 Mechanised Birg, Hissar Cantt, Hissar (7 Nos.)	10 HP
20.	88 Mechanised Birg, Hissar Cantt, Hissar (1 No.)	5 HP
21.	Forest Production Centre, Karnal	20 kW
22.	D.F.O. Office, Karnal	5 HP
23.	Urja Gram, Paluwas, Bhiwani	5 HP
24.	Urja Gram, Rahuka, Gurgaon	20 kW

Out of these units, 11 units were installed for pumping of water and the rest 25 for power generation application. To arrive at a quick overview of the status of these

units the results have also been compiled in a tabular form [Table – 3.2]. It can be seen that most of these units are not working. However, some units installed for private users have worked for some time and a few are still in working condition. The detailed status report of each of these units segregated cluster wise is provided in the following pages. This comprises of the information of the site, exact system configuration as well as the current status summary based on the actual site inspection and the attempts that were made on many of these units to operate by the team as per the agenda. To arrive at the true picture, the facts as they are, have been presented under the status summary, without any comments or remarks from the survey team professionals.

Table 3.2: Status summary of installed Gasifier systems in Haryana

Capacity		Application	Total number of units	User type			Present status
kW	HP			Govt.	Urjagram	Pvt	
3.75	5	Pumping	4	4	-	-	3-not working 1-not traceable
7.5	10	Pumping	7	7	-	-	Not traceable
5.0	-	Power	3	3	-	-	Not working
10.0	-	Power	1	1	-	-	Not working
20.0	-	Power	14	7[+]	4[+]	3*	+ not working * 2 units not working Please see remarks
40.0	-	Power	4	2[A]	-	2[B]	[A] Never worked [B] 1-unit in operation 1–unit not working
100.0	-	Power	3	-	-	3[C]	[C] 1-unit worked till the management changed 2-units not working
Total			36	24	4	8	

Remarks

* Out of these 3 units, 1 unit operated perfectly for about 2 years since installation till some major snag developed. However, no user support was provided to rectify the problem, to add to it by that time price of fuel (biomass) also went up making the unit economically non-viable.

3.1 *Survey results*

Cluster – SIRSA *No. of units* -- 01

1] User Info

Mr. Surender
Leeser
Suresh Cotton Oil & General Mill
Sirsa Tel: 22039

[This unit was leased to the present owner by Mr. Hindpal and Mr. Surender Goyal, M/s Choudhary Surja Ram Cotton Ginning and Pressing Factory, Kalanwali (Sirsa), Tel: 22039 which was the old name of this company]

System info

Application	:	Power generation
Gasifier make, model, Sr. No.	:	COSMO, 100kWe, CP94-100E
Year of commissioning	:	1993 – 1994
Engine make	:	Ruston and Hornsby (I) Ltd.
Alternator rating [kVA, Amps, Hz]	:	140 kVa, 194.8 Amps, 50 Hz

Status Summary

- Gasifier is not in operation. Engine operates in full diesel mode alone when required.
- Accessories e.g. blower, motor, water pump are missing.
- The present owner is not aware of any gasifier operations as he did not get either any records or any training from the previous owner. Physical observation reveals that gasifier may have been used sparingly, during commissioning only.
- Power is available throughout the day and so there is no need to operate the gasifier-genset.
- Cost of firewood is high, also since the industry is situated about 45 kms from Sirsa town, transportation cost for procurement of wood is substantial.
- As per the present owner the gasifier was supplied under large subsidy close to almost 100% including the central and state component.

Degraded state of gasifier and peripherals due to being idle

Cluster – PANCHKULA *No. of units --* 03

1] User Info

Mr. Rameshwar
Deputy Superintendent
Research and Training
Forest Training Institute
Pinjore, Distt. Panchkula

System info

Application : Power generation
Gasifier make, model, Sr. No. : ANKUR, 40kWe, BG – 40/015
Type Elect.
Year of commissioning : 1991
Engine make : Kirloskar
Alternator rating [kVA, Amps, Hz] : Kunal 48.5 kVa, 50 Hz

Status Summary

- Never operated after commissioning, not even the genset in full diesel mode.
- Complete system intact. Only problem due to aging and being idle.
- Need for captive power generation does not exist because of very little power cuts.
- Already having a small Hero Honda generator to tackle such short power cuts.
- System was originally conceived to supply the power to the office as well as the colony. However, because of the above points, the need never came up.
- The operator who was trained for gasifier operations was later transferred but no substitute was found, as a result presently nobody knows gasifier operations.
- The main power cabling from the gasifier-genset unit to the office/residential complex was never laid due to lack of funds.
- No fund was allocated for the operation and maintenance of the unit.
- The unit was installed under 100% subsidy [Central 80% + State 20% and free civil works] for the complete package which also includes the genset.
- Sufficient amount of biomass and necessary labor easily available.

Status of 40 kWe unit at Forest Training Institute, Pinjore. Full system intact but never used

2] User Info

Late Mr. Malikhan Singh
Atta Chakki (community utility)
Urja Gram Village Haripur
Block Rai Pur Rani, Dist: Panchkula

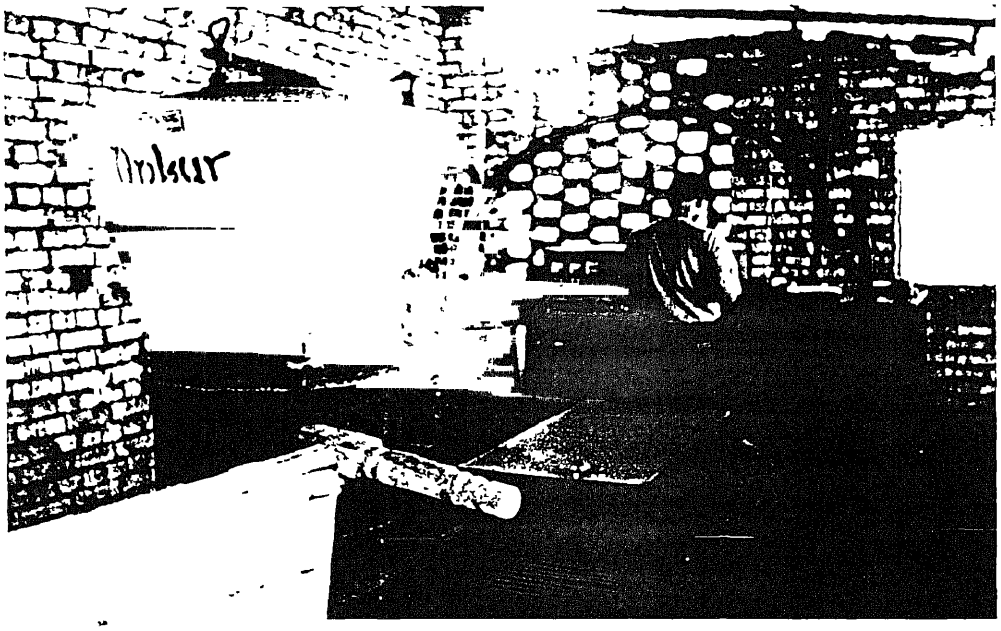
System info

Application : Power generation
Gasifier make, model, Sr. No. : ANKUR, 20kWe, AG/20E/609
Year of commissioning : 1993
Engine make : Escorts T-73-01-002.1.0
Alternator rating [kVA, Amps, Hz] : 25 kVa, 50 Hz

Status Summary

- Gasifier operated for a maximum duration of 50 hrs. since installation.
- Total engine operation since installation 425 hrs.
- Presently both gasifier and the engine are out of order.
- Fabric filter of the gasifier was badly damaged which indicates substantial tar and particulate inflow into the engine.
- Proper gasifier operation and maintenance training is missing
- Level of education (awareness) very low to handle such devices. Operational expertise for the gasifier engine unit does not exist.
- User financially weak and finds it impossible to invest on the maintenance of the system.
- The user, due to financial constraints, has sold out the Atta chakki, for which the gasifier unit was installed.
- Biomass is available for such small gasifier.
- The unit was installed under 100% subsidy [Central 80% + State 20% and free civil works] for the complete package which also includes the genset.

Status of 20 kWe unit at Urja Gram, Haripur.
Unit out of order and damaged



3] **User Info**

Mr. Ajit Vashisht
RMS Ceramics
Village Golpura, Block Raipur Rani
Distt. Panchkula   Tel: 01734-50048

System info

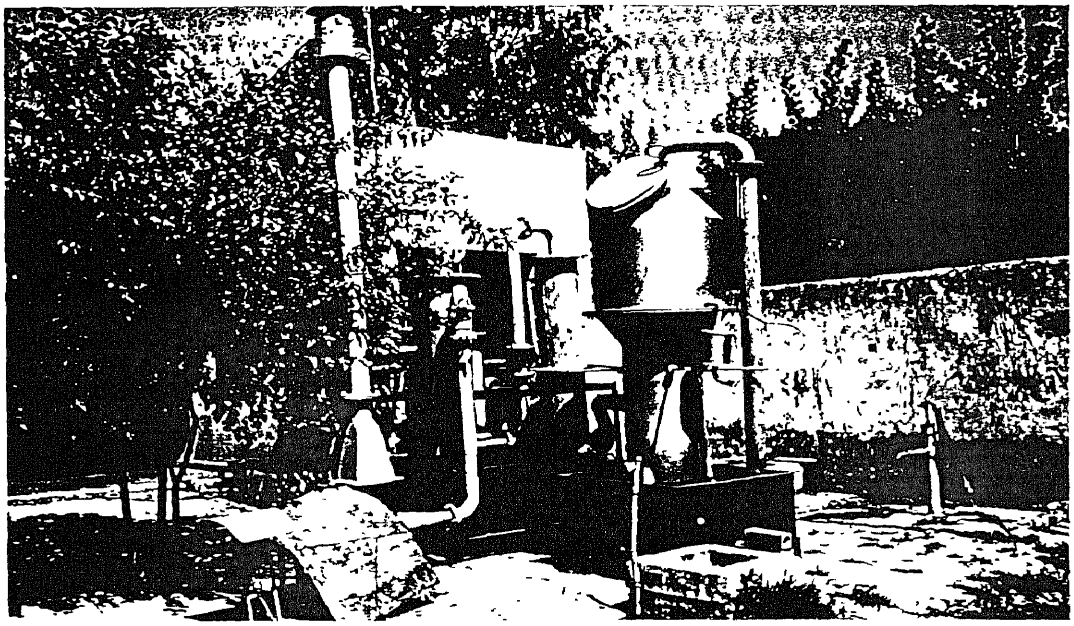
Application : Power generation
Gasifier make, model, Sr. No. : ASTRAL ENGINEERS, PANCHKULA, 40kWe
Year of commissioning : January 1998
Engine make : Kirloskar
Alternator rating [kVA, Amps, Hz] : 62.5 kVa, 50 Hz

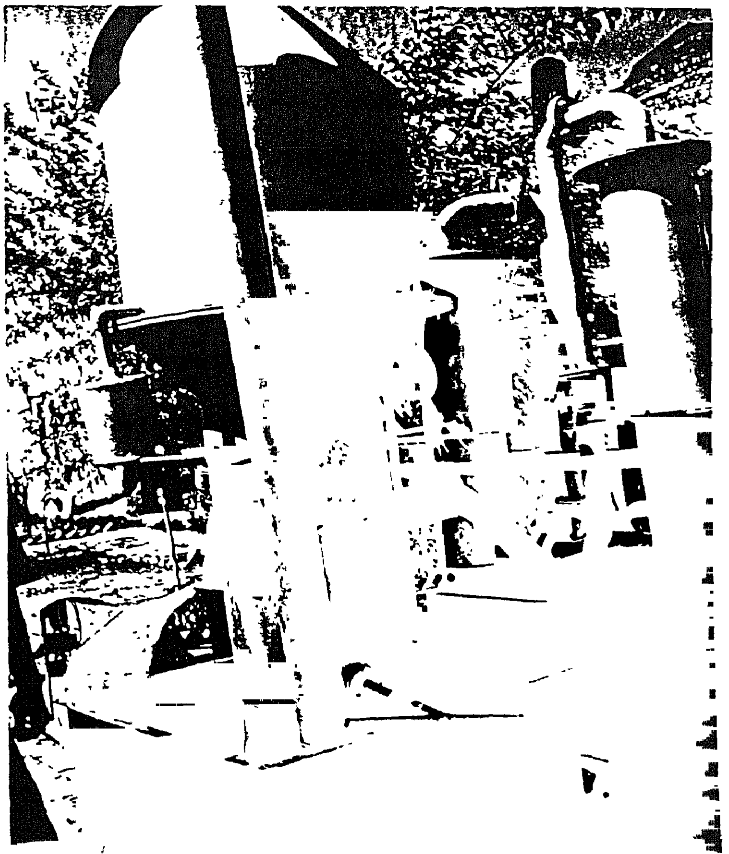
Status summary

- Recent installation.
- Grid power reliable. Unit in working order, operated only about 20 hrs. since installation.
- User appears to be happy.
- Present cost of wood Rs. 4.0/kg [as told by user] makes the gasifier based power generation completely loss making process. It is therefore strange how the user is not realizing the issue.
- User also gave some unrealistic performance data about the savings achieved, as listed below:
  (a) wood consumption 40-60 kg every four hours = 10 -15 kg/hour
  (b) dual fuel mode diesel consumption about 4.0 litres per hour

  Whereas the realistic data for the above system should have been:
  (a) wood consumption approximately 40 kg/hr
  (b) dual fuel mode diesel consumption about 4.0 litres per hour at a load of 40 kW.
- System cost Rs. 3.0 lakes without diesel engine out of which the subsidy component is Rs. 2.1 lakhs [Central Rs 1.14 lakhs + State Rs. 0.96 lakhs]

40 kWe unit at RMS Ceramics, Raipur Rani. Recent installation





Cluster – AMBALA ***No. of units -- 01***

1] **User Info**

Mr. Amarjit Singh
Oberoi Furniture House
Rai Market
Ambala Cantt Tel: 643642

System info

Application : Power generation
Gasifier make, model, Sr. No. : MM FABRICATORS, 20kWe
Year of commissioning : 1990
Engine make : Kirloskar
Alternator rating [kVA, Amps, Hz] : 25 kVa, 50 Hz

Status summary

- This unit installed in the private sector has been properly utilized for two years
- The unit was originally operated with the saw mill waste generated in house.
- With occurrence of major problem with the gasifier (breakage of air nozzles) it could not be repaired because of non-availability of spares, as well as no response from the manufacturer
- Presently the market rate of wood chips @ Rs. 3.50/- per kg if sold out, makes the gasifier operation non-viable at this site.
- User selection was proper however with regard to present biomass cost gasifier based power generation does not make sense. To add to it the current power scenario is good in the city of Ambala.
- The unit was installed under 100% subsidy [Central 80% + State 20% and free civil works] for the complete package which also includes the genset.

20 kWe unit at Oberoi Furniture House, Ambala Cantt. System operated for 2 years, presently out of order, shown are broken air nozzle, dismantled burner, and sand bed filter with relatively clean sand.

Cluster – JIND *No. of units -- 02*

1] User Info

Mr. Ram Milan
Kanya Gurukul gharal
Kharal, Jind

System info

Application : Power generation
Gasifier make, model, Sr. No. : ANKUR, 20kWe, AG – 20E/608
Year of commissioning : 1993
Engine make : Escorts, T – 73 – 01 - 002 – 1 - 0
Alternator rating [kVA, Amps, Hz] : 30 kVa, 41.7 Amps, 50 Hz

Status summary

- No shortage of grid electricity
- The use of gasifier genset setup is only to handle the short power cuts. Since the duration of such power cuts is very small; say half an hour, operation of genset in full diesel mode is preferred by the user due to ease of operation (quick start) as well as because it is less laborious. User therefore has no motivation to operate the gasifier.
- On the other hand for gasifier operations sufficient amount of wood and adequate in-house labor is available.
- Gasifier unit along with peripherals is intact, however, would require major overhaul to begin regular usage and hence no attempt was made by the team to operate it.
- As per the user records the gasifier–genset operation in dual-fuel mode is only 30 hrs., while the genset has already clocked operation of 650 hrs. by now, since installation.
- The unit was installed under 100% subsidy [Central 80% + State 20% and free civil works] for the complete package which also includes the genset. The cost of the unit was Rs. 3.04 lakhs.

Unused and degraded 20 kWe unit at Kanya Gurukul, Kharal, Jind

2] **User Info**

Mr. Kamal Singh
Kanya Gurukul
Genda Khera
Jind

System info

Application	Power generation
Gasifier make, model, Sr. No.	ANKUR, 20kWe, AG – 20E/606
Year of commissioning	1993
Engine make	Escorts, T – 73 – 01 - 002 – 1 - 0
Alternator rating [kVA, Amps, Hz]	30 kVa, 41.7 Amps, 50 Hz

Status summary

- No shortage of grid electricity
- The use of gasifier genset setup is only to handle the short power cuts. Since the duration of such power cuts is very small; say half an hour, operation of genset in full diesel mode is preferred by the user due to ease of operation (quick start) as well as because it is less laborious. User therefore has no motivation to operate the gasifier.
- On the other hand for gasifier operations sufficient amount of wood through captive plantations and adequate in-house labor for chipping and operations is available.
- Gasifier unit along with peripherals is intact, however, would require major overhaul to begin regular usage.
- As per the user records the gasifier–genset operation in dual-fuel mode is only about 1 – 2 hrs., while the genset has already clocked operation of 630 hrs. by now, since installation.
- The unit was installed under 100% subsidy [Central 80% + State 20% and free civil works] for the complete package which also includes the genset. The cost of the unit was Rs. 3.04 lakhs

Unused and degraded 20 kWe unit at Kanya Gurukul, Genda Khera, Jind

Cluster – YAMUNANAGAR *No. of units* -- 06

1] **User Info**

Prof. Swaran K Aggarwal
Director
Rajan Steel
Plywood Manufacturing & Saw Mills
21, Industrial Estate, Phase I
Yamuna Nagar Tel: 50343/Fax: 01732-50895

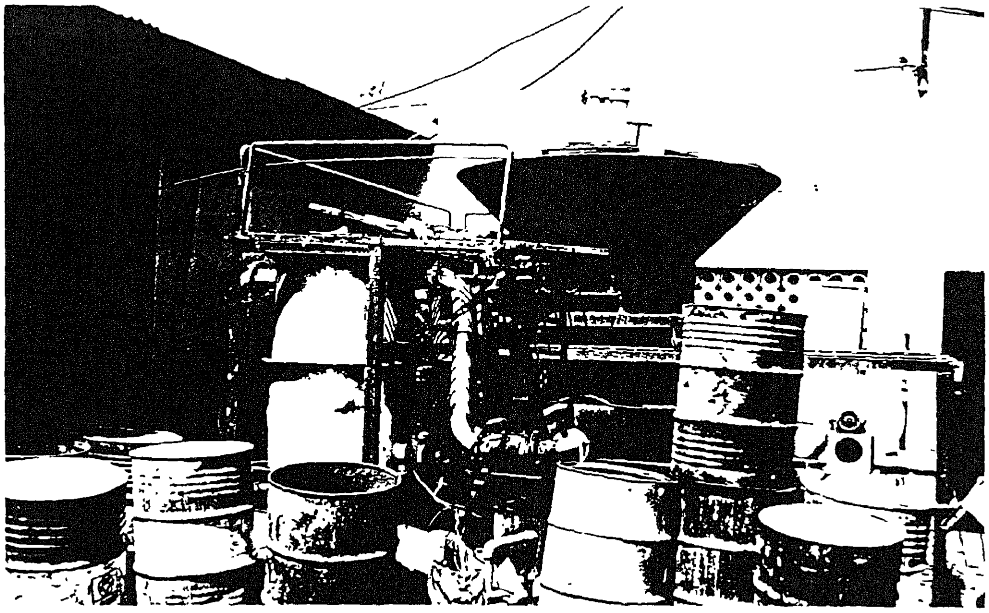
System info

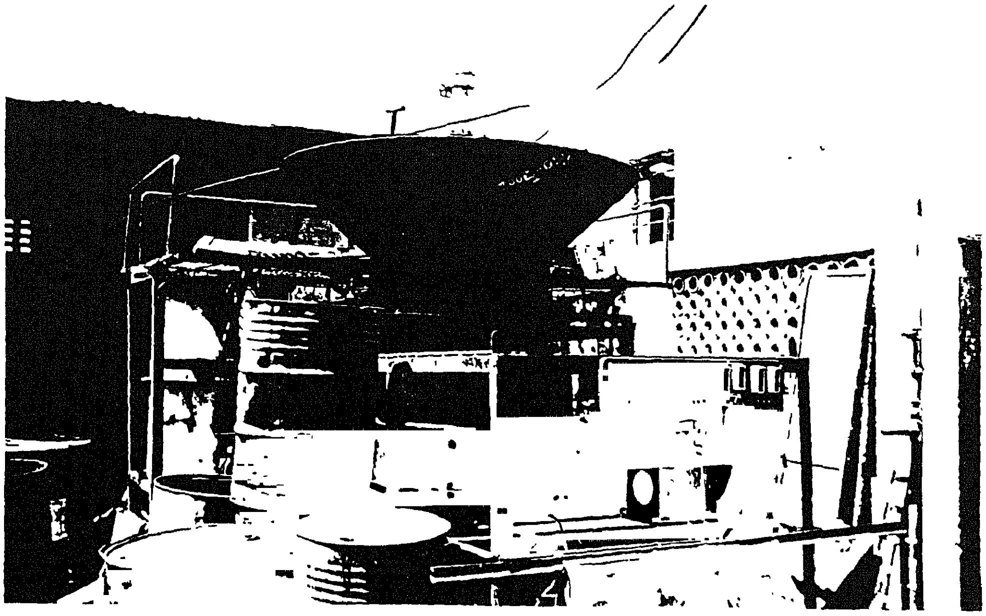
Application : Power generation
Gasifier make, model, Sr. No. : COSMO, 100 kWe, 100E1 – 09/04
Year of commissioning : 1995
Engine make : Greaves
Alternator rating [kVA, Amps, Hz] : 160 kVa, 50 Hz

Status summary

- Cosmo product engineers could not operate the gasifier even for one hour after installation.
- According to user, manufacturer never put any effort to run the gasifier and when they were contacted they did not respond.
- Wood is available in plenty, since the user also has Teak and plywood industry from which enough waste is generated.
- Gasifier unit is intact and is in place in a reasonably good condition.
- Currently power cuts are of the order of 1-2 hours per day and for which the user does not want to operate the gasifier even if it is OK. This is because to operate genset fully on diesel is found easier by the user as well as the cost of such diesel consumption is well within the affordable limit for them. User also does not like the idea to operate his industry full time on gasifier-genset configuration to avoid over-use of his genset. In summary user is not interested to use the gasifier.
- The unit was installed under 100% subsidy [Central 80% + State 20% and free civil works] applicable for gasifier only.

100 kWe unit at Rajan Steel, Yamuna Nagar.
Systems never operated for even 1 hour. Presently abandoned





2] **User Info**

Prof. Swaran K Aggarwal
Director
Rajan Steel
Plywood Manufacturing & Saw Mills
21, Industrial Estate, Phase I
Yamuna Nagar Tel: 50343/50347/Fax: 01732-50895

System info ***[****As per the Records of HAREDA & the local DRDA office****]**

Application : Power generation
Gasifier make, model, Sr. No. : COSMO, 40 kWe
Year of commissioning : 1995
Engine make : Not available
Alternator rating [kVA, Amps, Hz] : Not available

Status summary

- **UNIT IS NOT TRACEABLE. USER REFUSED TO SHOW US THE UNIT AND EVEN AVOIDED ACKNOWLEDGING THAT THEY EVER GOT THE UNIT.**
- As per the record this unit also has been supplied under the same subsidy scheme i.e., 100% subsidy [Central 80% + State 20% and free civil works] applicable for gasifier only.

3] **User Info**

Mr. Vivek Jindal
Haryana Industries
Plywood manufacturing
Khajuri Road
Yamuna Nagar Tel: 21963

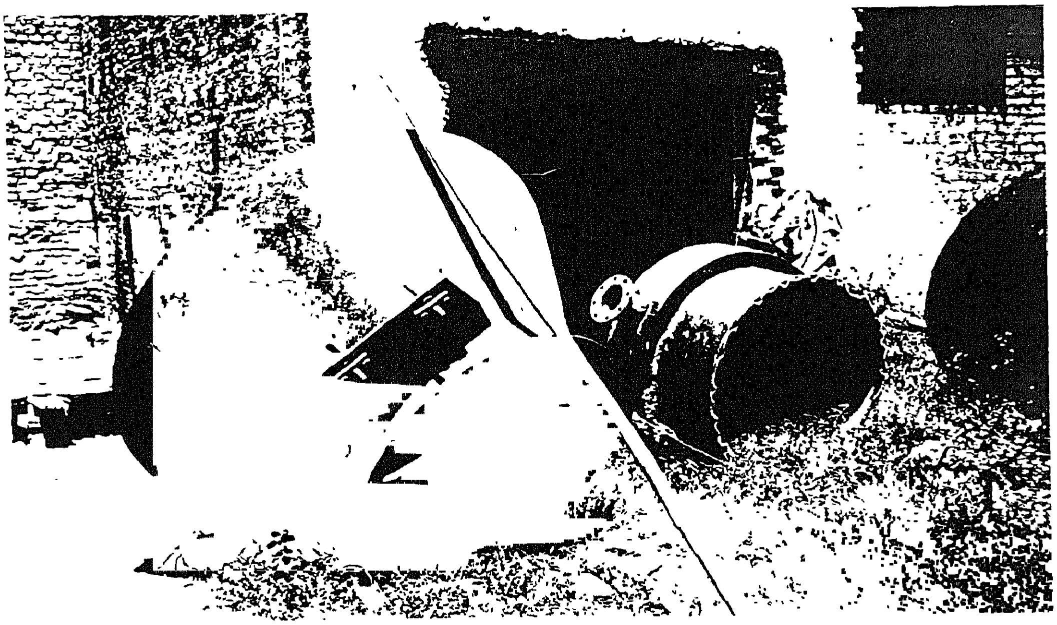
System info

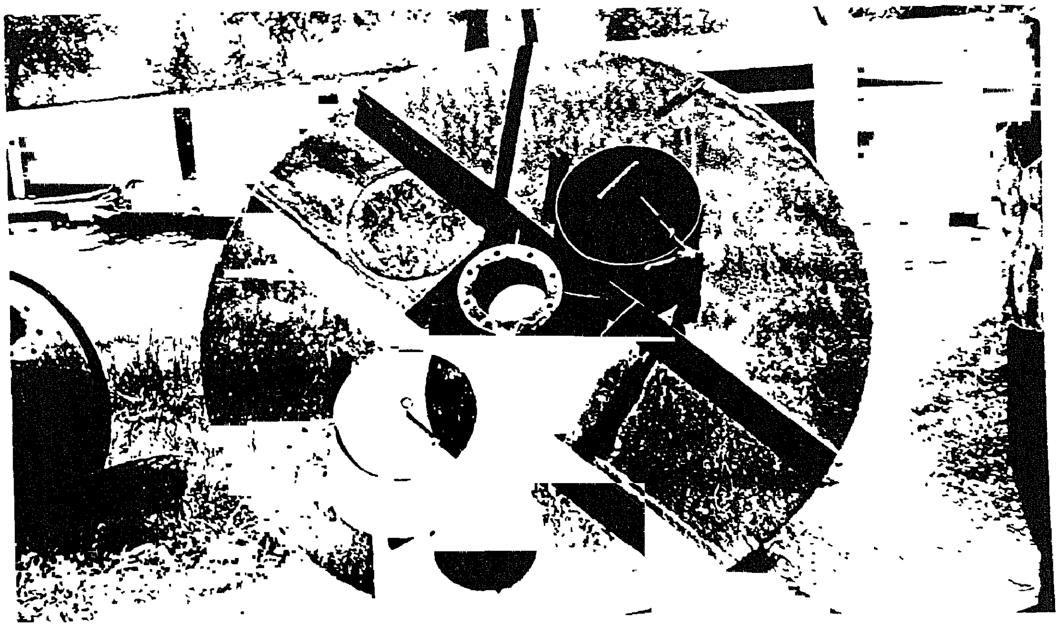
Application : Power generation
Gasifier make, model, Sr. No. : COSMO, 100 kWe
Year of commissioning : 1995
Engine make : Not available
Alternator rating [kVA, Amps, Hz] : 125 kVA

Status summary

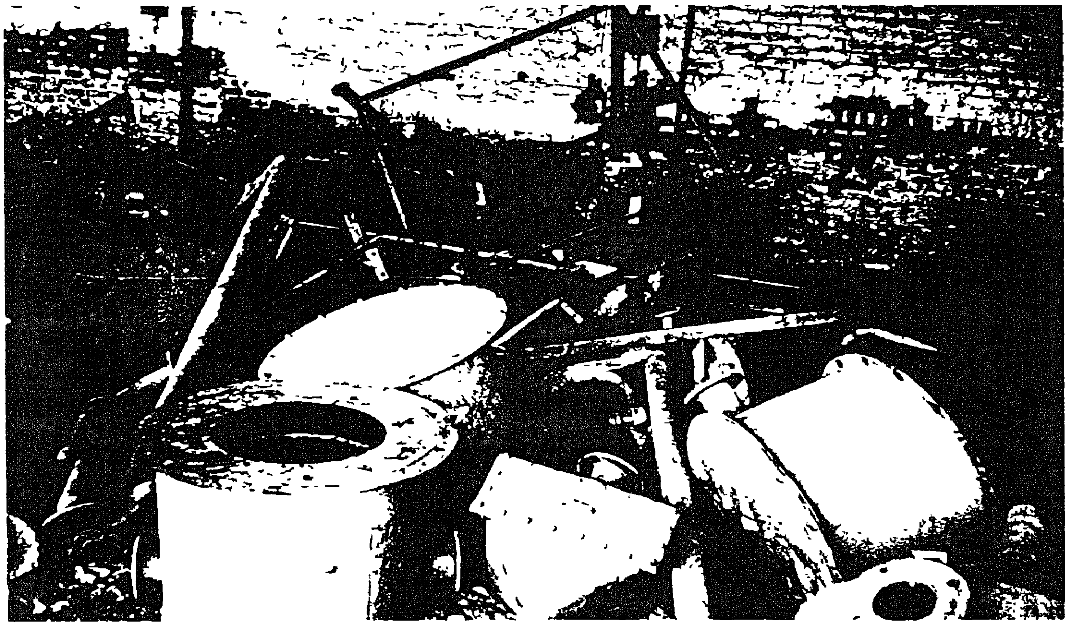
- Cosmo product engineers were not able to operate the gasifier after installation.
- According to user they never got any response from the manufacturers when they tried to contact them.
- Wood is available in plenty and the market price of wood is approx. Rs. 1.50/kg
- Power cuts are 1-2 hours/day (current)
- File and manual properly maintained
- Gasifier dismantled and kept at one corner
- The fact that system had been operated for very less duration is authenticated by the status of the glass wool of the fine filter of the system.
- Considering the good power situation the user does not find the gasifier based power generation an attractive proposition and hence is not interested to use the unit either.
- As per the record this unit also has been supplied under the same subsidy scheme i.e., 100% subsidy [Central 80% + State 20% and free civil works] applicable for gasifier only]

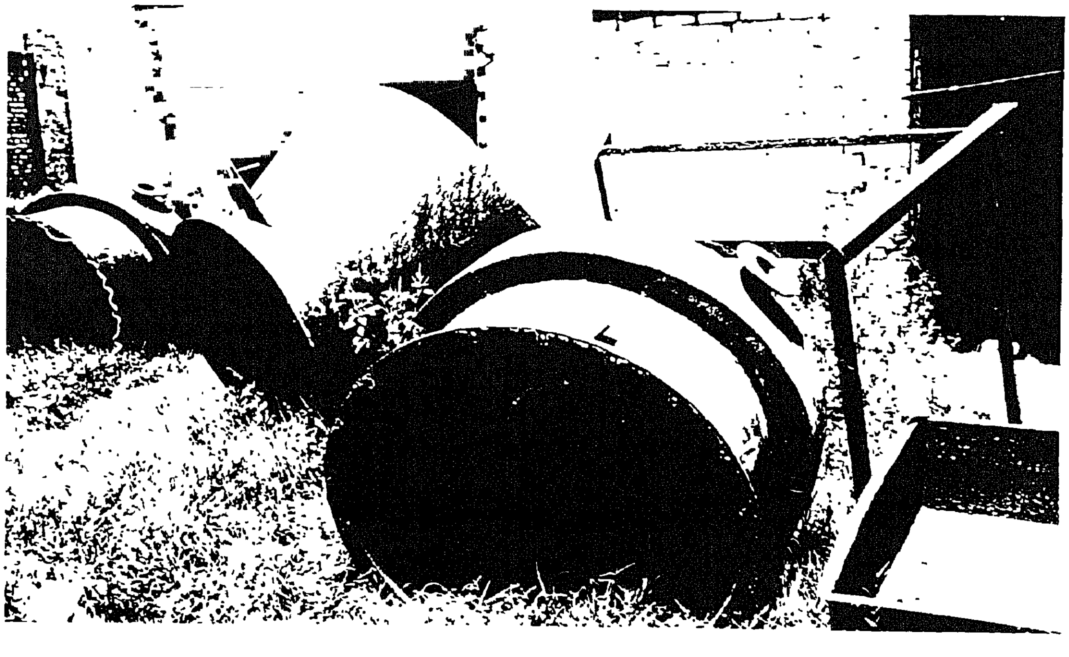
100 kWe unit at Haryana Industries, Yamuna Nagar.
Systems never operated. View of dismantled gasifier hopper





View of combustion zone and dumped and degraded gasifier subsystems





4] User Info

District Forest Office
Yamuna Nagar 135 001

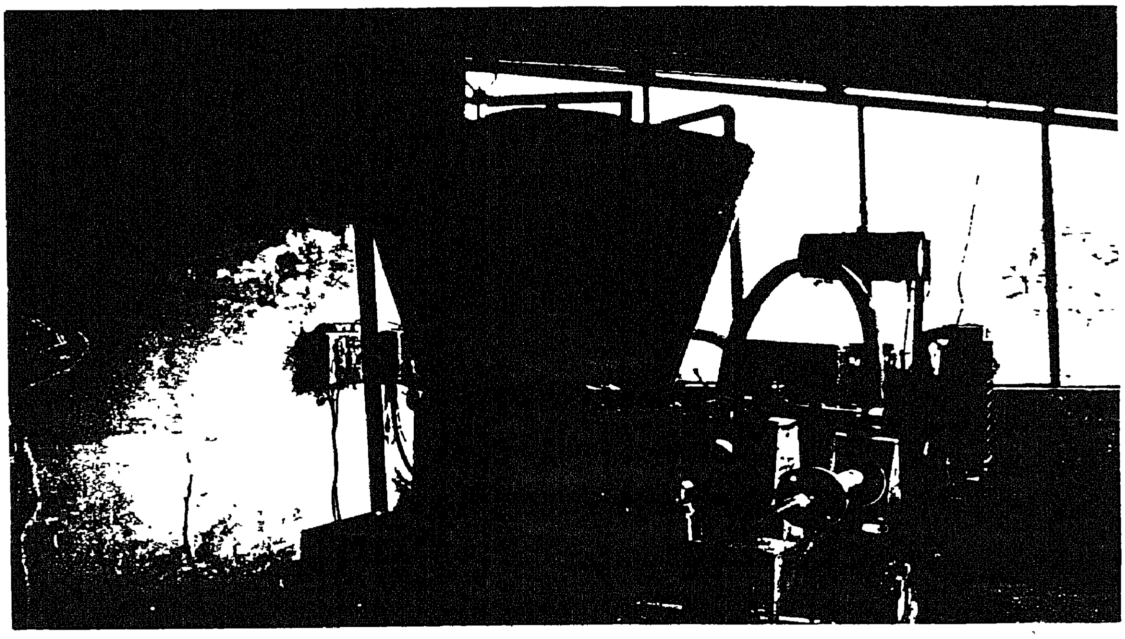
System info

Application	Power generation
Gasifier make, model, Sr. No.	ANKUR, 20 kWe, AG – 20E/607
Year of commissioning	1993
Engine make	Ruston and Hornsby, BS 55 141, 43 BHP
Alternator rating [kVA, Amps, Hz]	30 kVA

Status summary

- Biomass availability is plenty at the user end. There is no requirement of the unit since the power cuts are very low.
- Present power demand of the campus is 80kW while the gasifier engine unit capacity is 20kW
- Awareness of gasifier operation does not exist since the nozzle was found to be choked, gas pipe deformed and the cooling-cleaning pump was not able to lift water.
- No motivation to operate the gasifier since the original set of officers got transferred.
- Basic power tariff Rs. 3.50/unit (current cost)
- As per the records gasifier operated only for about 100 hrs [50 hrs. during commissioning and about 50 hrs. afterwards] till date. The engine is in operation for about 2 hrs. per day regularly in full diesel mode.
- The team attempted to revive the gasifier. However because of long misuse resulting in failure of various components and the bad shape of the electrical wiring, it was not possible.
- The unit was installed under 100% subsidy [Central 80% + State 20% and free civil works] for the complete package which also includes the genset. The cost of the unit was Rs. 2.64 lakhs including genset

View of degraded and abandoned 20 kWe gasifier at District Forest Office, Yamuna Nagar



5] User Info

Mr. Satwant Singh
S S Engineering Corporation
11-12, Industrial Estate, Phase I
Yamuna Nagar 135 001 Tel: 51463

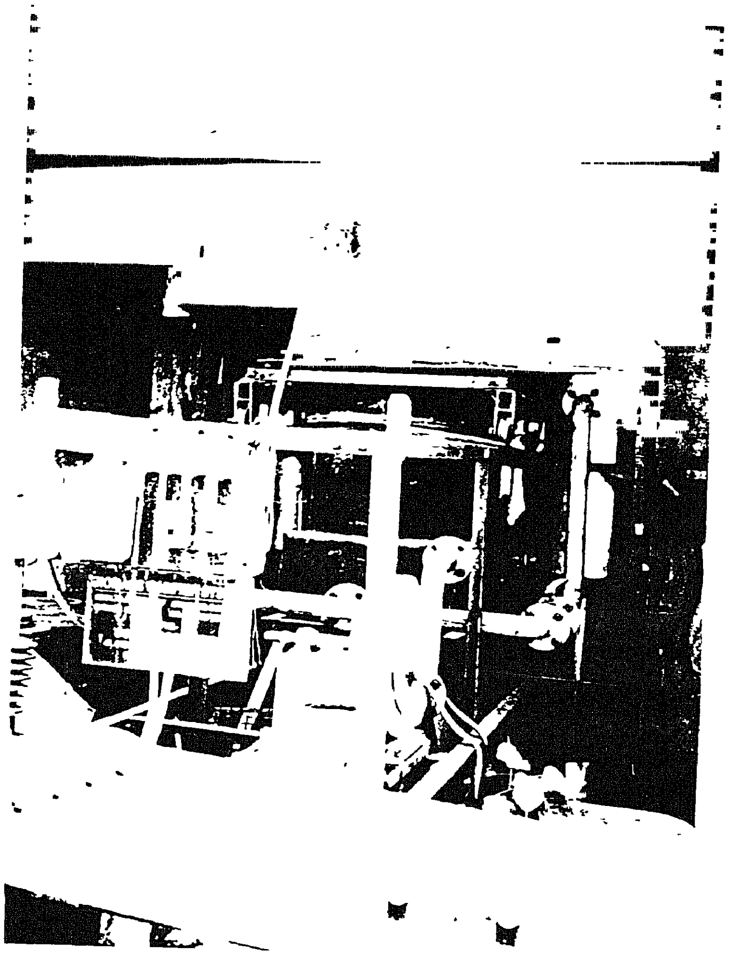
System info

Application : Power generation
Gasifier make, model, Sr. No. : COSMO, 20 kWe, CP–95–20E– 007
Year of commissioning : 1995
Engine make : Ruston [2 Cylinder 15 years old engine]
Alternator rating [kVA, Amps, Hz] : 19.6 kVA

Status summary

- According to the user, at the present cost of wood [Rs. 1.50/kg], gasifier based power generation at this place is not financially viable for a usage of about 1-2 hours per day. It could be viable if the system operates for long hours every day.
- Basic cost of electricity (current) Rs. 3.50/unit.
- Reasonably good electricity supply (cuts 1-2 hours per day, max.)
- User is not interested to operate the unit and never operated it since installation due to the reasons mentioned above.
- Presently all gasifier peripherals have degraded due to aging and being left idle. The team could not operate it as the unit requires major overhaul and replacement of some parts.
- Unlike other case the user is happy about the training he received in gasifier operation.
- The gasifier and peripherals [excluding the genset] have been supplied under 100% subsidy [Central 80% + State 20% and free civil works].

View of spoilt and unused 20 kWe unit at S.S. Engg. Corporation, Yamuna Nagar



6] **User Info**

Jamuna Engineering Corporation
Harbanspura, Workshop Road
Near ITI
Yamuna Nagar 135 001

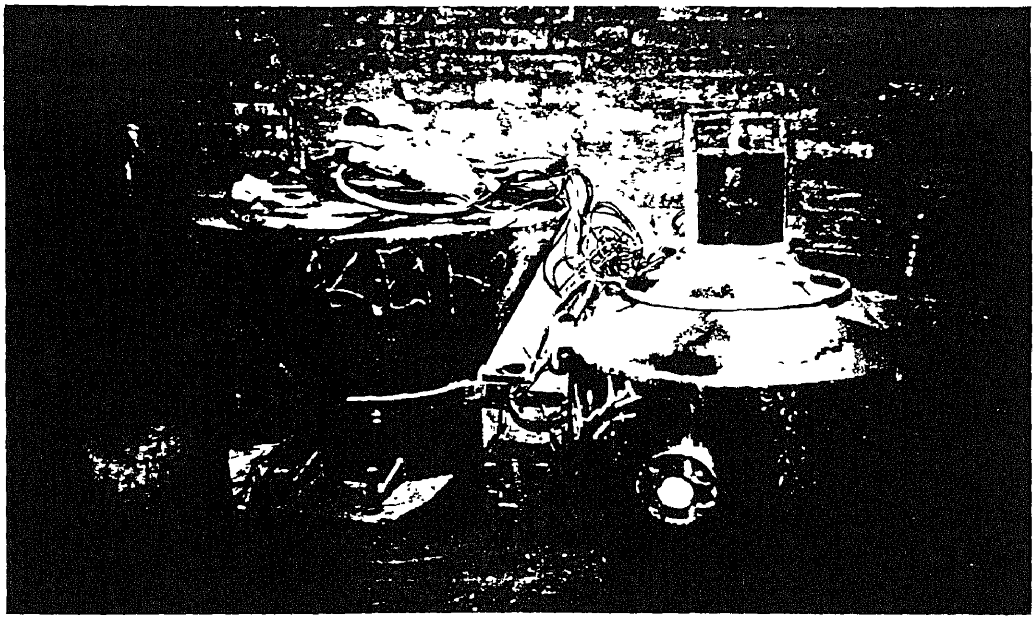
System info

Application	:	Power generation
Gasifier make, model, Sr. No.	:	COSMO, 20 kWe, Not available
Year of commissioning	:	1995
Engine make	:	Hindustan
Alternator rating [kVA, Amps, Hz]	:	20.0 kW

Status summary

- The user is not interested to operate the gasifier because:
  - The time taken to start and connect it to the engine is 1 hour.
  - Engine is unable to take the full load in dual fuel mode.
  - Power requirement is minimal since the power cuts are for a maximum for 1 – 2 hours and hence the operation is not economically viable.
  - The space requirement for the unit is large and there is space constraint in this industry
- The gasifier was operated for a total of 10 hrs since installation.
- Presently the unit is dismantled and dumped.
- Basic power tariff Rs. 3.50/unit (current cost)
- The gasifier and peripherals [excluding the genset] have been supplied under 100% subsidy [Central 80% + State 20% and free civil works].

View of dismantled and corroded 20 kWe unit at Jamuna Engg. Corporation, Yamuna Nagar



Cluster – HISSAR *No. of units -- 19*

] **User Info**

Dr. Y K Yadav
Alternate Energy Division Head
University, IREP Technical Backup Unit
College of Agriculture, Engineering and Technology
C.C.S. Haryana Agricultural University
Hisar 125 Tel: 31171/72/73 ext. 4206

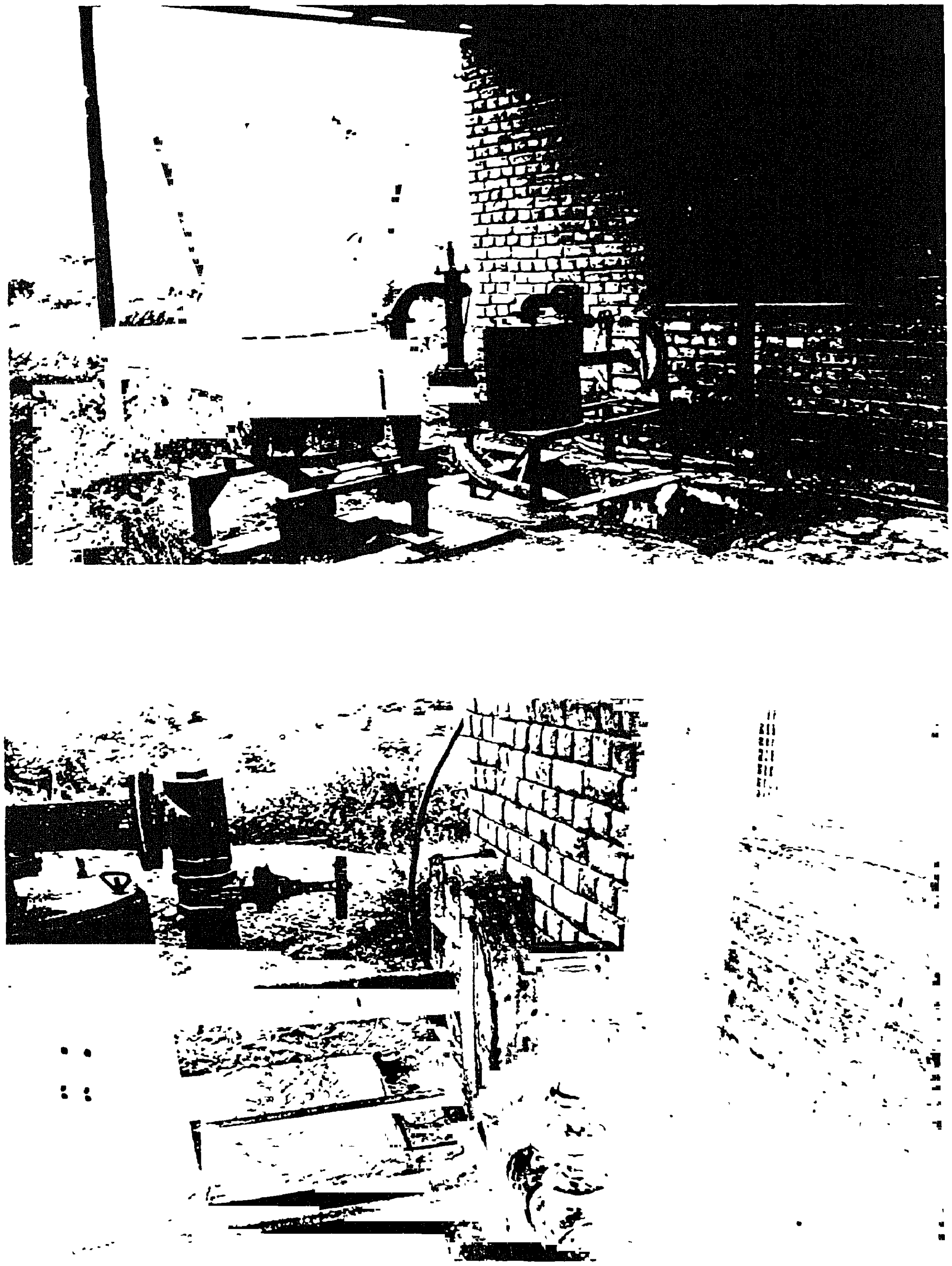
System info

Application : Power generation
Gasifier make, model, Sr. No. : ANKUR, 40 kWe, BG – 40/015
Year of commissioning : 1987
Engine make : Escorts,
Alternator rating [kVA, Amps, Hz] : 62.5 kVA, 50Hz

Status summary

- The system was supplied for deep borewell pumping.
- No shortage of grid electricity.
- Gasifier has been operated for only about 20 hours since installation, while the engine is being used in full diesel mode once in a while. This is so since there is practically no incentive to run the gasifier to save small quantity of diesel as the usage is very little.
- The gasifier and its components have been badly degraded due to no-use and maintenance. The cooling water pump is missing.
- Availability of wood difficult in case of longer usage. Also, the present cost of wood Rs.2/kg makes the system economically unviable
- Trained people were transferred hence there is lack of interest in usage.
- The unit was installed under 100% subsidy [Central 80% + State 20% and free civil works] for the complete package which also includes the genset.

View of 40 kWe unit which is not used for many years and presently in a bad state at Haryana Agricultural University, Hissar.



2] **User Info**

Mr. Jile Singh
Ex Surpanch
Urja Gram
Sandhlana
Hissar

System info **[As per the Records of HAREDA & the local DRDA office]**

Application : Water pumping
Gasifier make, model, Sr. No. : 5 HP, Not traceable
Year of commissioning : 1986
Engine make : Not available, Most of the parts are missing

Status summary

- **THE GASIFIER AND MOST OF ITS ACCESSORIES ARE NOT TRACEABLE, THE CYCLONE AND VENTURI SCRUBBER ARE FOUND AT THE SARPANCH'S OFFICE.**
- **THE PUMP ENGINE IS IN VERY BAD SHAPE WITH MOST OF ITS PARTS MISSING.** _
- As told by the ex –sarpanch, a trained operator was appointed by the Govt. of Haryana at the time of commissioning. However, after some time the operator was called back. The villagers on the other hand do not have any motivation to operate it, so they dismantled and sold out various parts.
- As learnt by the team this is the same case with other renewable energy products e.g., solar PV street lights etc. in this village
- The unit was installed under 100% subsidy [Central 80% + State 20% and free civil works] for the complete package which includes the engine and pumpset.

5HP pumping unit of Urja Gram, Sandhlana, Hissar, found at the office of Sarpanch

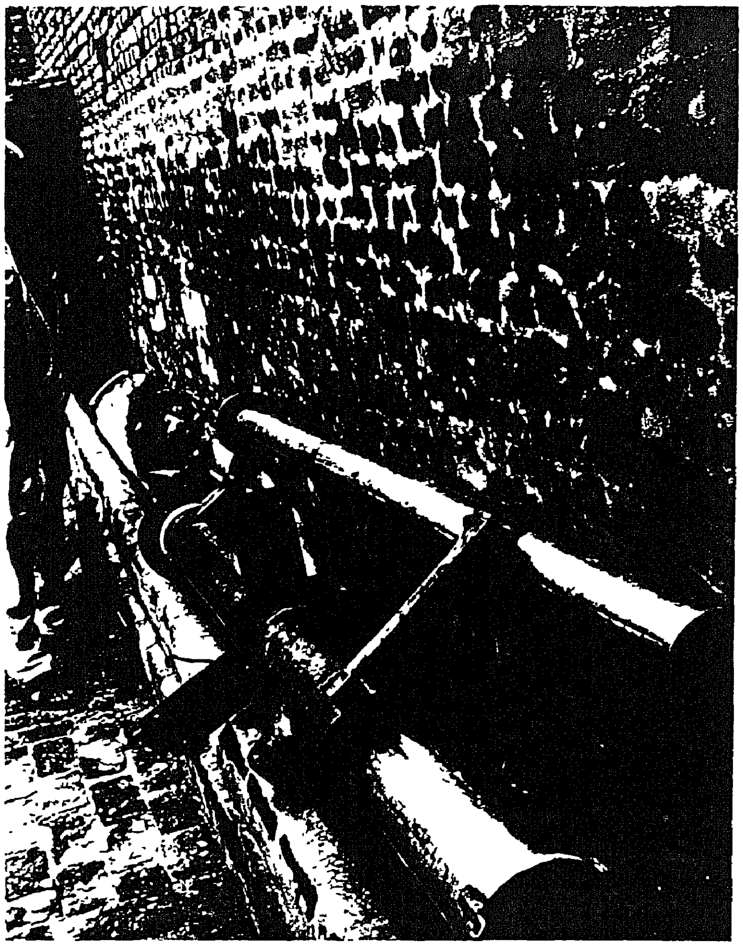


Plate 1: Only traceable part of the gasifier i.e., cooling –cleaning subsystem

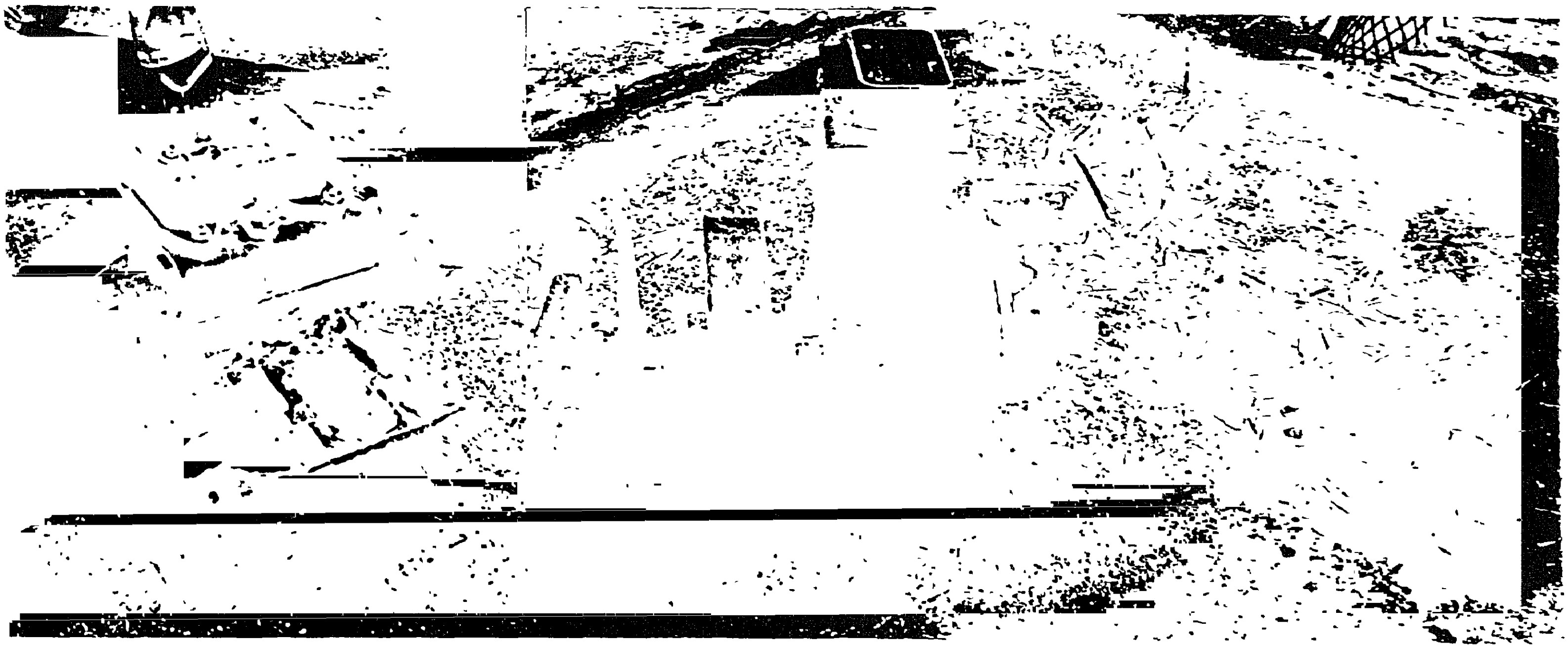


Plate 2 & 3: View of completely degraded engine with cutter

3] **User Info**

Major M Gopalan (DQ)
C/o 56 APO
88 Armed Brdg.
Hissar Cantt Tel: 20013, ext. 2727, 2725
Installed at: Commanders House

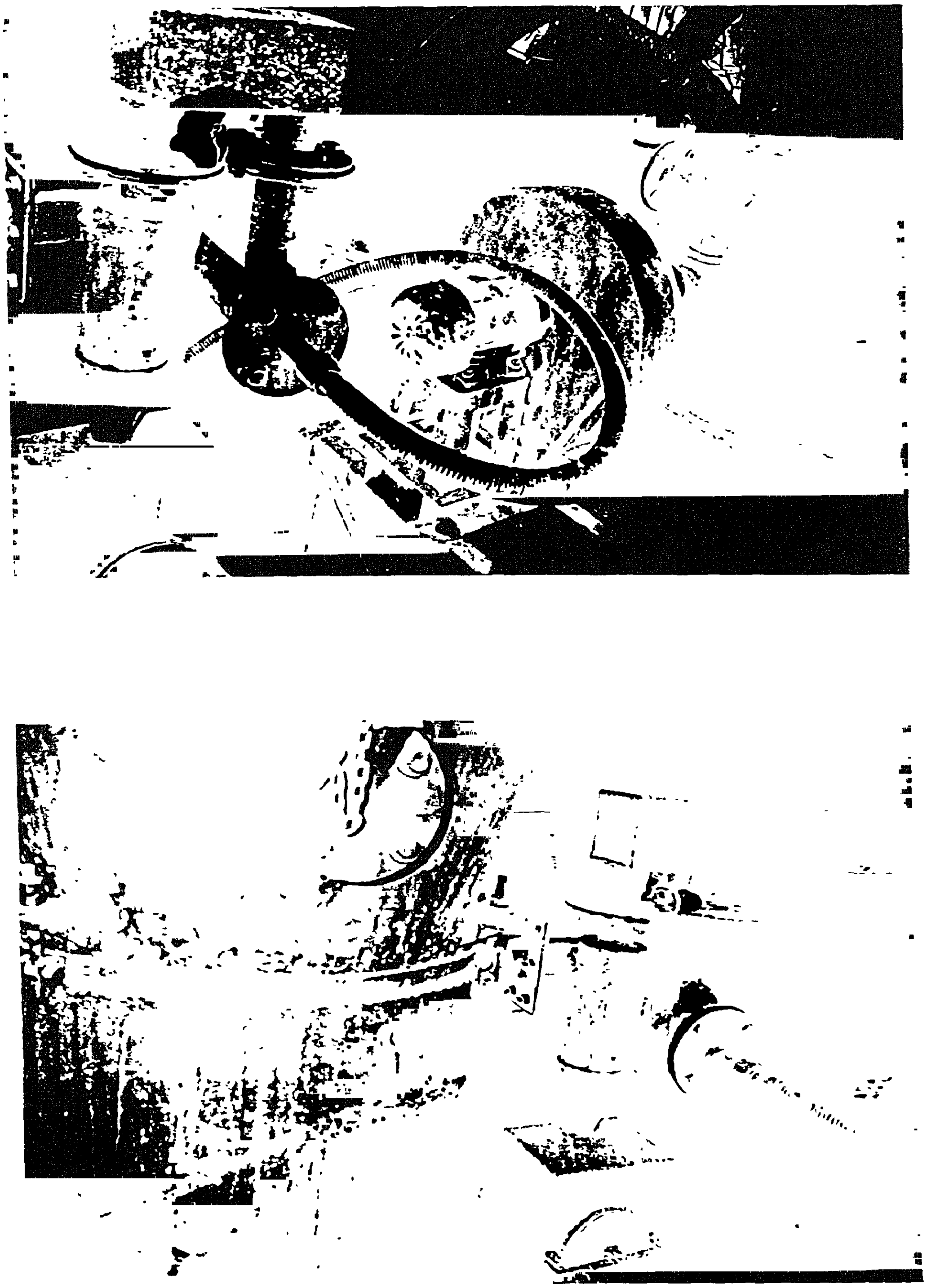
System info

Application : Power generation
Gasifier make, model, Sr. No. : ANKUR, 20 kWe, AG20E – 605
Year of commissioning : 1995
Engine make : Escorts
Alternator rating [kVA, Amps, Hz] : 30 kVA, 50Hz

Status summary

- User never operated the gasifier since installation because they never wanted it due to:
  - Easy availability of diesel fuel without any limit on the quantity consumed.
  - Easy operation of engine on full diesel mode
  - They find it difficult to acquire and prepare wood for the gasifier due to lack of motivation.
- The gasifier and all its accessories are in a bad state of degradation due to non-usage. The cooling water pump is missing. Blower completely rusted due to water ingress. Venturi scrubber and fabric filter completely spoilt due to rusting and no maintenance.
- The unit was installed under 100% subsidy [Central 80% + State 20% and free civil works] for the complete package which includes the engine.
- **USER AGREED THAT THEY ACQUIRED THE GASIFIER SINCE THEY WERE GETTING D.G. SET COMPLETELY FREE.**

Different views of totally degraded 20 kWe gasifier at 88 Armoured Brigade, Hissar, due to non-usage



4] **User Info**

Major M Gopalan (DQ)
C/o 56 APO
88 Armed Brdg.
Hissar Cantt Tel: 20013, ext. 2727, 2725

Installed at: Officer's Mess

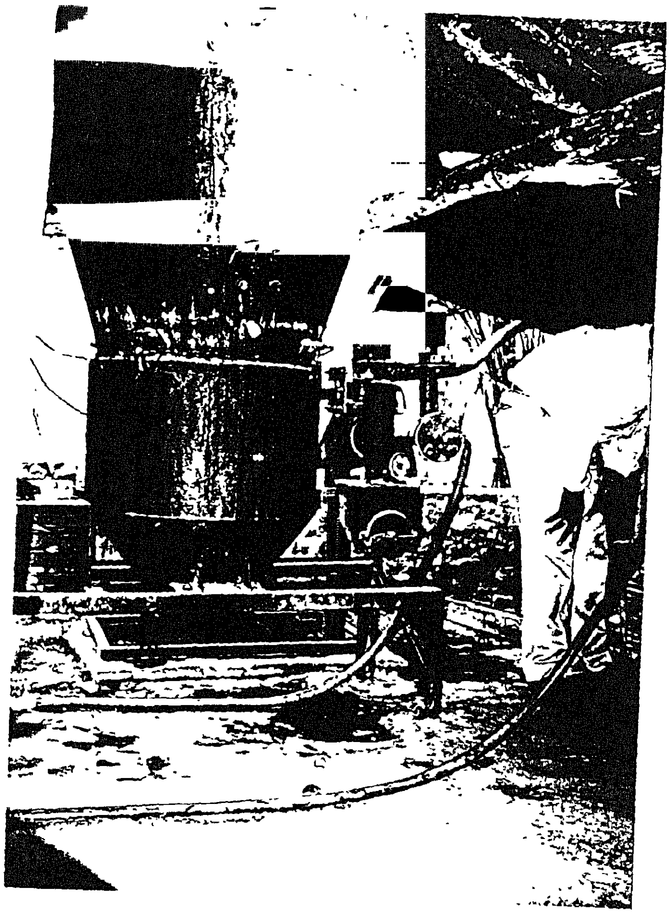
System info

Application	: Power generation
Gasifier make, model, Sr. No.	: ANKUR, 20 kWe, AG20E – 602
Year of commissioning	: 1995
Engine make	: Escorts
Alternator rating [kVA, Amps, Hz]	: 30 kVA, 50Hz

Status summary

- Same as case no. 3 above

Two views of the rusted 20 kWe unit at 88 Armoured Brigade, Hissar



5] **User Info**

Major M Gopalan (DQ)
C/o 56 APO
Hissar Cantt Tel: 20013, ext. 2727, 2725
Installed at: 57 Armed Brdg.

System info

Application : Power generation
Gasifier make, model, Sr. No. : ANKUR, 5 kWe, AG8P – 401
Year of commissioning : 1995
Engine make : Name plate missing
Alternator rating [kVA, Amps, Hz] : Not available

Status summary

- Same as case no. 3 above

6] User Info

Major M Gopalan (DQ)
C/o 56 APO
88 Armed Brdg/.
Hissar Cantt Tel: 20013, ext. 2727, 2725

Installed at: The administrative office of 88 armored Brigade

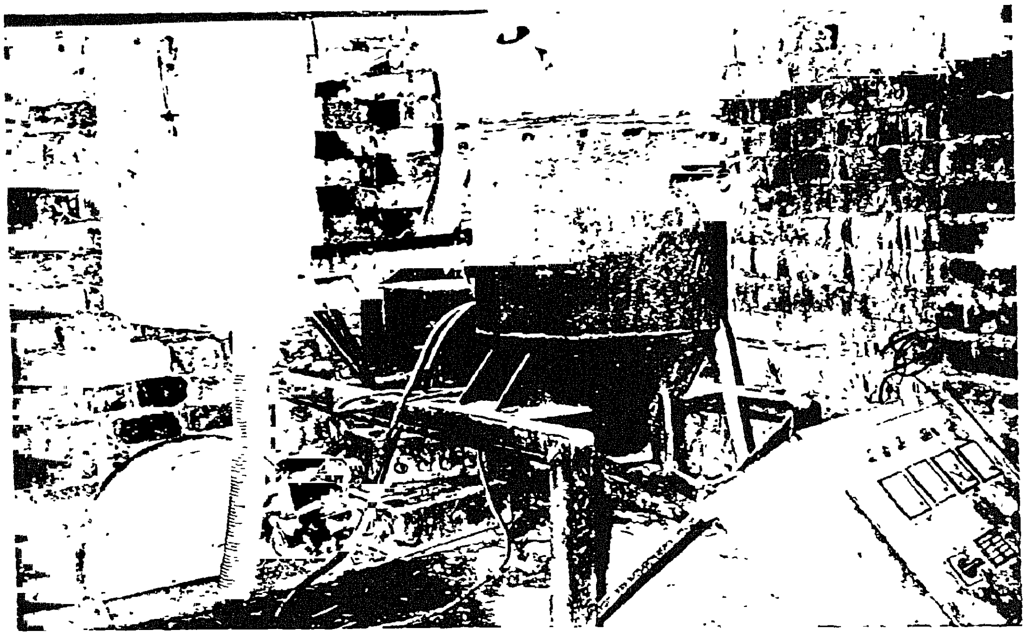
System info

Application : Power generation
Gasifier make, model, Sr. No. : ANKUR, 10 kWe, AG10 – 502
Year of commissioning : 1995
Engine make : Parry's
Alternator rating [kVA, Amps, Hz] : 20 kVA, 50 Hz

Status summary

- Same as case no. 3 above

Abandoned 10 kWe gasifier at 88 Armoured Brigade, Hissar



7,8,9] **User Info** ***THREE UNITS***

Major M Gopalan (DQ)
C/o 56 APO
88 Armed Brdg.
Hissar Cantt Tel: 20013, ext. 2727, 2725

System info *[As per the Records of HAREDA]*

Application	: Power generation
Gasifier make, model, Sr. No.	: 20 kWe, not available
Year of commissioning	: 1995
Engine make	: Not available
Alternator rating [kVA, Amps, Hz]	: Not available

Status summary

- **USER REFUSED TO SHOW US THE UNITS, HOWEVER STATED THAT THE GASIFIERS ARE NOT IN OPERATION WHILE THE ENGINES ARE WORKING AS ABOVE.**
- The unit was installed under 100% subsidy [Central 80% + State 20% and free civil works] for the complete package which includes the engine.
- **USER AGREED THAT THEY PROCURED THE GASIFIERS SINCE THEY WERE GETTING D.G. SETS COMPLETELY FREE.**

10 & 11] **User Info** **TWO UNITS**

Major M Gopalan (DQ)
C/o 56 APO
88 Armed Brdg.
Hissar Cantt Tel: 20013, ext. 2727, 2725

System info ***[As per the Records of HAREDA]***

Application : Power generation
Gasifier make, model, Sr. No. : 5 kWe, not available
Year of commissioning : 1995
Engine make : Not available
Alternator rating [kVA, Amps, Hz] : Not available

Status summary

- Same as in case no. 7 & 8 above

12 to 18] **User Info** *SEVEN UNITS*

Major M Gopalan (DQ)
C/o 56 APO
88 Armed Brdg.
Hissar Cantt Tel: 20013, ext. 2727, 2725

System info ***[As per the Records of HAREDA]***

Application : Water Pumping
Gasifier make, model, Sr. No. : 10 HP, not available
Year of commissioning : 1995
Engine make : Not available
Alternator rating [kVA, Amps, Hz] : Not available

Status summary

- **ALL 7 UNITS NOT TRACEABLE.**
- **USER SAID THEY NEVER RECEIVED THE UNITS AS PER THEIR RECORDS.**

19] **User Info**

Major M Gopalan (DQ)
C/o 56 APO
88 Armed Brdg.
Hissar Cantt Tel: 20013, ext. 2727, 2725

System info ***[As per the Records of HAREDA]***

Application	: Water Pumping
Gasifier make, model, Sr. No.	: 5 HP, not available
Year of commissioning	: 1995
Engine make	: Not available
Alternator rating [kVA, Amps, Hz]	: Not available

Status summary

- **UNIT NOT TRACEABLE.**
- **USER SAID THEY NEVER RECEIVED THE UNITS AS PER THEIR RECORDS.**

Cluster – **KARNAL** *No. of units – 02*

1] **User Info**

Mr. Krishan Chand
Forest Production Centre
Karnal

System info

Application	:	Power generation
Gasifier make, model, Sr. No.	:	ANKUR, 20kWe, AG 20E – 610
Year of commissioning	:	1993
Engine make	:	Escorts, T – 73 – 01 – 002 – 1 – 0
Alternator rating [kVA, Amps, Hz]	:	29 kVA, 41.7 Amps, 50 Hz

Status Summary

- Total engine operation since installation is 2430 hrs.
- As per the user's records the engine was operated in dual fuel mode for about 1 year and 3 months however, the physical inspection of the fabric filter which was never washed any time revealed that gasifier could not have been operated for more than 40 hrs till date.
- Gasifier and its components in bad shape due to no maintenance.
- Grid electricity is reliable and very less power cuts.
- Availability of wood waste plenty.
- User is not interested to use the gasifier because:
  - Power cuts are rare and short for which the user finds the diesel consumption of the engine in full diesel mode affordable. There is no motivation to save diesel
  - User is not inclined to do the extra labor required to operate the gasifier.
- The unit was installed under 100% subsidy [Central 80% + State 20% and free civil works] for the complete package which also includes the genset.

Two views of the unused and spoilt 20 kWe gasifier at Forest Production Centre, Karnal

2] User Info

D.F.O. Office
Karnal

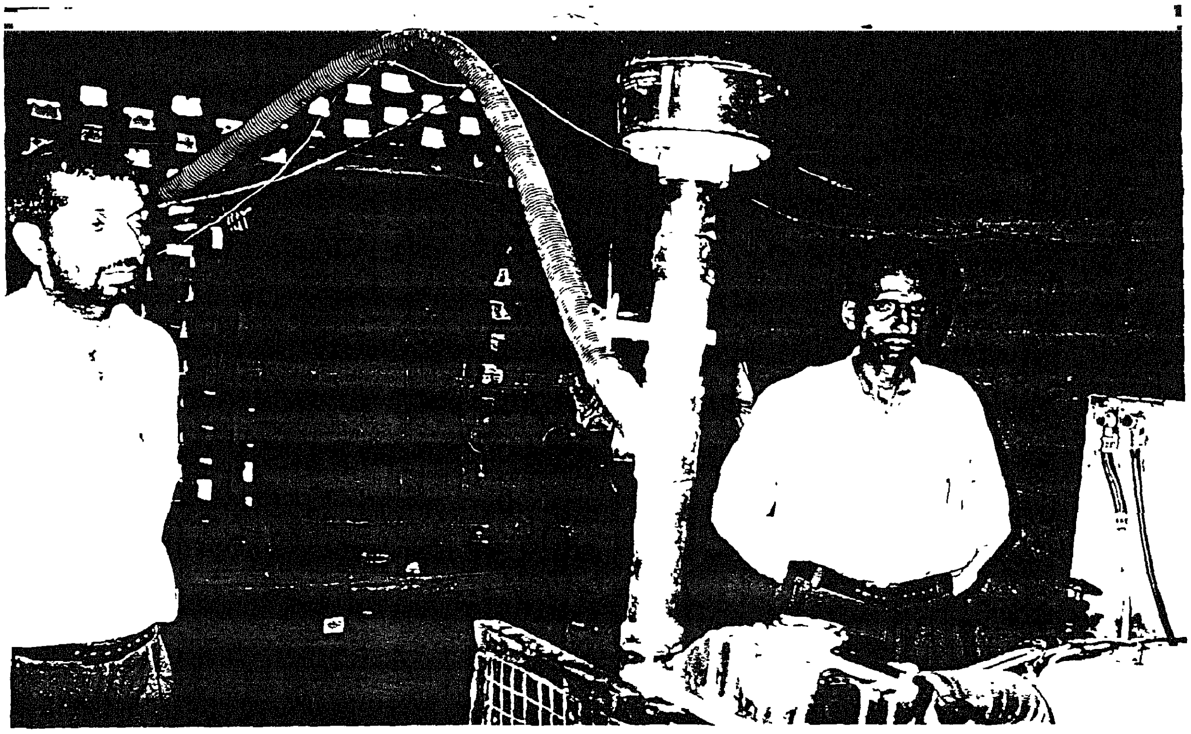
System info

Application	*: Power generation*
Gasifier make, model, Sr. No.	*: ANKUR, 5kWe, AG 5E – 404*
Year of commissioning	*: 1994*
Engine make	*: Not available, Engine spoilt*
Alternator rating [kVA, Amps, Hz]	*: Not available*

Status Summary

- A short while after commissioning the engine seized due to very high load connected. On the request of the user, manufacturer agreed to reimburse the cost of repair of the engine. The user dismantled it, but never got it repaired and presently many vital parts of the engine are missing.
- The unit therefore operated for a very short while. The trained operator was later transferred.
- Gasifier and its components in bad shape due to no maintenance.
- Grid electricity is reliable and power cuts are rare.
- Availability of wood waste plenty.
- User does not even have any interest to repair the engine and use it due to no requirement.
- The unit was installed under 100% subsidy [Central 80% + State 20% and free civil works] for the complete package which also includes the genset.

Bad shape of the gasifier and its subsystem due to no use and maintenance at District Forest Office, Karnal



Cluster* -- BHIWANI** ***No. of units – 01

1] **User Info**

Mr. Surender Kumar
Ex Surpanch
Urja Gram
Paluwas
Bhiwani

System info *[*As per the Records of HAREDA & the local DRDA office *]*

Application	:	Water pumping
Gasifier make, model, Sr. No.	:	5 HP, not traceable
Year of commissioning	:	1986
Engine make	:	Not traceable

Status summary

- **THE COMPLETE UNIT IS NOT TRACEABLE.**
- **THE SARPANCH DENIED THAT ANY SUCH UNIT WAS EVER INSTALLED THERE. HE ADDED THAT THERE IS NOT EVEN ANY DOCUMENT WITH THEM.**
- **THE EX-SARPANCH WAS NOT AVAILABLE FOR COMMENTS.**
- **WE LOCATED THE ONLY POND IN THAT VILLAGE ASSUMING THAT IT COULD BE THE PROBABLE SITE. HOWEVER, LOCAL ENQUIRIES WITH SENIOR VILLAGERS ALSO SUBSTANTIATED THE CLAIM OF THE SARPANCH.**
- As all other Urja Gram units this too was installed under 100% subsidy [Central 80% + State 20% and free civil works] for the complete package which includes the engine and pumpset.

Cluster –* GURGAON** ***No. of units – 01

1] **User Info**

Urja Gram
Rahuka
Gurgaon

System info

Application : Power Generation
Gasifier make, model, Sr. No. : ANKUR, 20 kWe, Not available
Year of commissioning : 1992
Engine make : Escorts
Alternator rating [kVA, Amps, Hz] : 29 kVA, 50 Hz

Status summary

- The gasifier was never operated as the inside paint of fabric filter unit is unspoiled and no traces of any soot or tar in the whole of gas line.
- The cooling water pump, fabric filter, cutter motor missing.
- Many vital parts of the engine namely nozzles, dial gauges, air filter, batteries, radiator pipes etc. are missing. The engine is also in a bad shape due to lack of use and maintenance.
- There is no need for this unit in the Urja gram as the power situation is good and so there is no motivation to operate it.
- The trained operator has also left so at present there is no operator.
- As all other Urja Gram units this too was installed under 100% subsidy [Central 80% + State 20% and free civil works] for the complete package which includes the engine and pumpset.

----------x-x-x--------

4. Detailed performance analysis of 40kW gasifier at Pinjore

To carry out the detailed performance analysis, the 40 kWe gasifier-based power generation unit at Pinjore was chosen. As explained previously in Chapter 2 the original intention was to test 20 kW power generation unit installed at Urja Gram, Rehuka, Gurgaon. However, realizing that this unit required major overhaul and as peripheral devices which are missing, a decision for the detailed test was made in favour of the former.

The survey brought out that this was one of the rare installations which has been intact with all peripheral equipments. However, since the unit was never operated after installation, it called for major repair and maintenance work before it could be started. The unit consisted of an ANKUR biomass gasifier complete with all peripherals having capacity of 40 kW with matching D.G set. The unit was installed to supply power to the Forest Institute complex as well as its staff quarters. While the identification of this site was ideal for the demonstration of gasification technology in terms of availability of biomass, it was not so ideal regarding user need, as the power situation at Pinjore is reasonably good. In addition to that the Institute already has a small genset to handle the occasional power cuts. As a result there was no requirement for a large unit at this site and hence it was never operated even in full diesel mode. The necessary power supply cable to the Institute was never laid and the unit had been kept completely isolated and untouched since the operator was transferred at a later date after installation.

As a result of non-functioning of the unit various sub components were in a bad condition. The motor pump coil was short-circuited, resulted in rewinding the coil of the motor. The gascut and motor seal were degraded and started leaking. New motor seal and gascuts were replaced in the pump. The foot valve also needed to be replaced. On the generator side the radiator was leaking badly due to a damage caused while unloading at the time of installation. This called for repair of the fin tubes. The oil pressure pipes had also developed leakage which needed repair.

All the above as well as other maintenance was undertaken to prepare the unit for a testrun. During the weeklong exercise the support from the user and the DRDA office was outstanding which had really contributed to make the unit operational.

The earlier designs of gasifiers needed charcoal (in the combustion zone) in addition to wood for ignition while starting for the first time or after assembly. Since charcoal was not available locally it was procured from Chandigarh, and after a proper clean up of the gasifier about 25 kgs of charcoal and around 250 kgs of cut wood was filled in it. The seal of hopper door and hopper reactor was also adjusted to ensure proper operation of the unit. Since there was no grid connection to the unit, the engine had to be operated to run only the gasifier. All electrical wiring which were old were rectified to operate the gasifier by running the engine.

4.1 Test procedure and results

Necessary equipments for the test which included tar and dust sampling units, Junker's gas calorimeter, digital thermometer, stop watch etc. were taken from TERI. The gasifier was first ignited by flaring the gas. Total time taken for ignition was 9.00 minutes. The gas was allowed to flare for long duration to observe the flame stability. It was found that flame was getting extinguished quite often indicating non-uniform gas quality. This was also substantiated while measuring diesel replacement as explained later. The gas quality varies depend upon the fuel flow in the fire box of the gasifier. The frequent variation in the gas quality is observed due to occurrence of the fuel bridging inside the fuel hopper of the gasifier, even though there is a vibrator provided to avoid occurrence of bridging, by creation of regular vibration in the fuel bed. The vibration effect of the vibrator on the gasifier hopper was not seems to be sufficient enough to solve the bridging problem. The effect of vibrator was found to be as an enhancement of smooth operation however this alone was not able to completely control the fluctuations in the gas quality which was clear from the visuable observation of non-stable flame. The flame temperature for a rich fuel air mix was found to be in the reasonable range of 912°C to 960°C. Inspite of the fact that a properly clean gas cooling and cleaning subsystem consisting of Venturi scrubber and fabric fitter was on line and the gas quality was bad and smoky. A quick rise of the water used for cooling and cleaning purpose, which is stored in the trench is gaining temperature to a tune of 5°C from 29°C to 34°C was observed in a span of only 3 hours of gasifier operation. While this indicated efficient functioning of cooling subsystems however, it also pointed to the need of water replacement which may be needed in case the gasifier is made to run for more than eight hours continuously.

4.1.1 Tar and dust measurement

Tar and dust was measured by sampling the gas through filter paper of 0.8 micron quartz filter paper was used during the experiments. The filter papers were ensured moisture free and taken to the field by keeping them in the desicator. After completion of the experiment the paper was kept back in the desicator to maintain the moisture free level. The tar and dust collected was measured by the weight gained by the filter paper.

The filter paper is placed in a cassette and the inlet of the cassette is connected with the sampling port at the outlet of the fabric filter. Outlet of the cassette is connected to a gas flow meter inlet. The flow meter outlet is connected with the suction side of a high R.P.M. wolf blower. The blower outlet connected to a bunsen burner for flaring the gas.

During sampling of the gas the flow rate also observed to get the gas-sampling rate. Gas cleaning water temperature, gas temperature, at the outlet of the gasifier and the filtering system were measured simultaneously.

4.1.2 Gas calorific value measurement

Junker's gas calorimeter along with necessary accessories like digital thermometer, stop watch, measuring jar, blower etc. was taken to the field for measuring the gas calorific value. The gas is sampled from the outlet of the fabric filter using a wolf blower through a digital gas flow meter. The gas flow rate is measured using stopwatch and the flow meter readings. Water flow rate is measured using stopwatch and measuring jar. Temperature rise in the water is measured by using digital thermometer. Gas inlet temperature was measured to get the calorific value per normal meter cube.

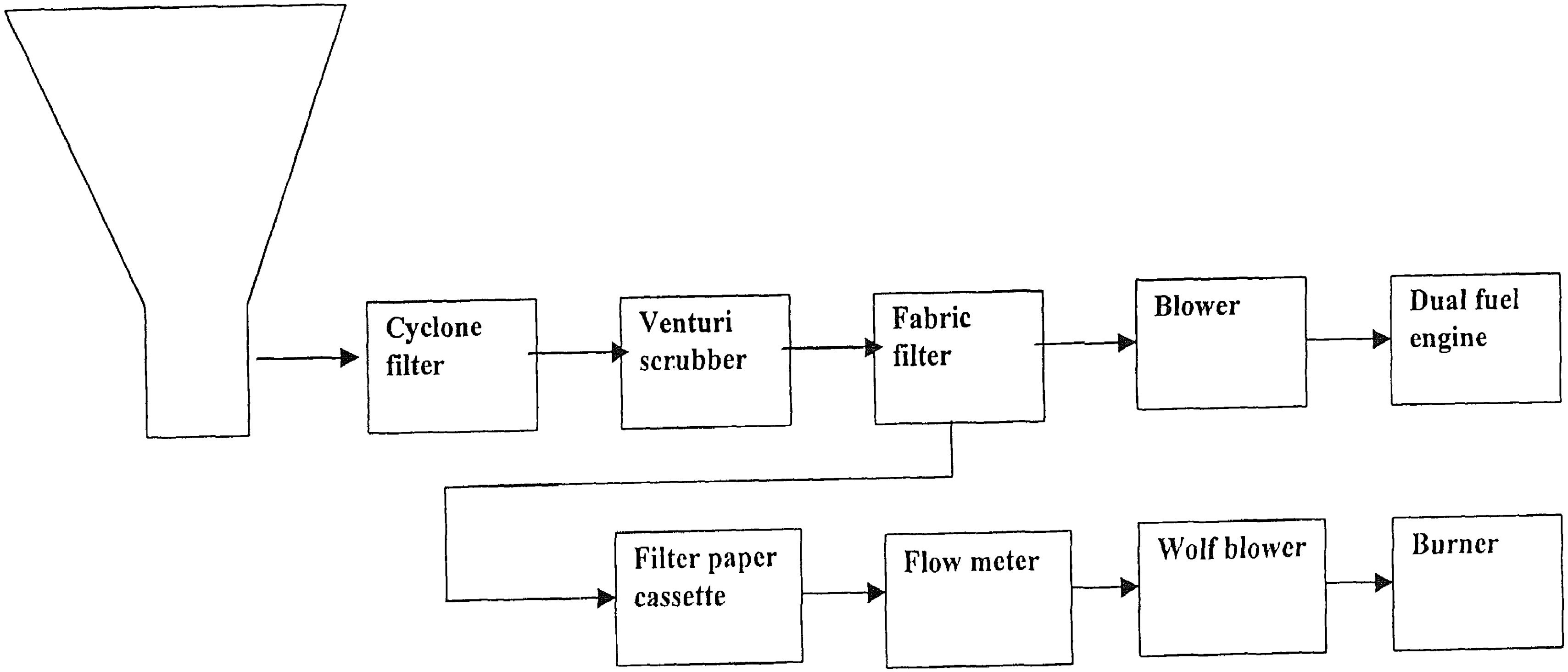
4.1.3 Diesel replacement measurement

Diesel replacement is measured by allowing a known quality of diesel for a measured period. Diesel path of the engine is modified such a way the diesel can be supplied from the normal diesel storage for continuous running or to supply diesel from a separate line at a known flow rate/quality.

The gen set is not connected with any external appliances to utilize the full capacity of the electric power generator. By running the all electrical components commonly used in the system along with the wolf blower etc. A 7 kW load is applied

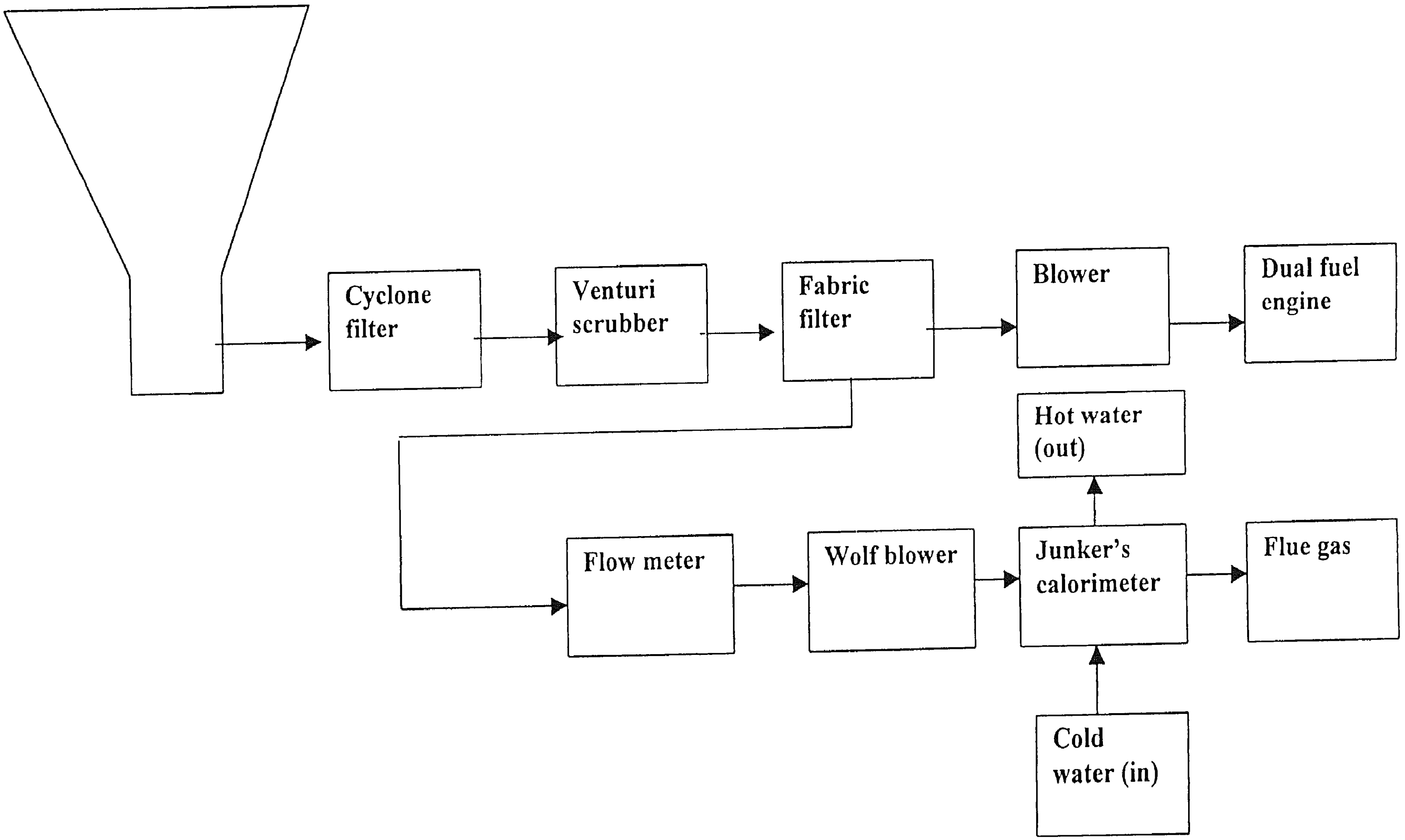
The flow diagram gives the detail of the experimental set up used during tar and dust measurement.

Tar and dust measurement



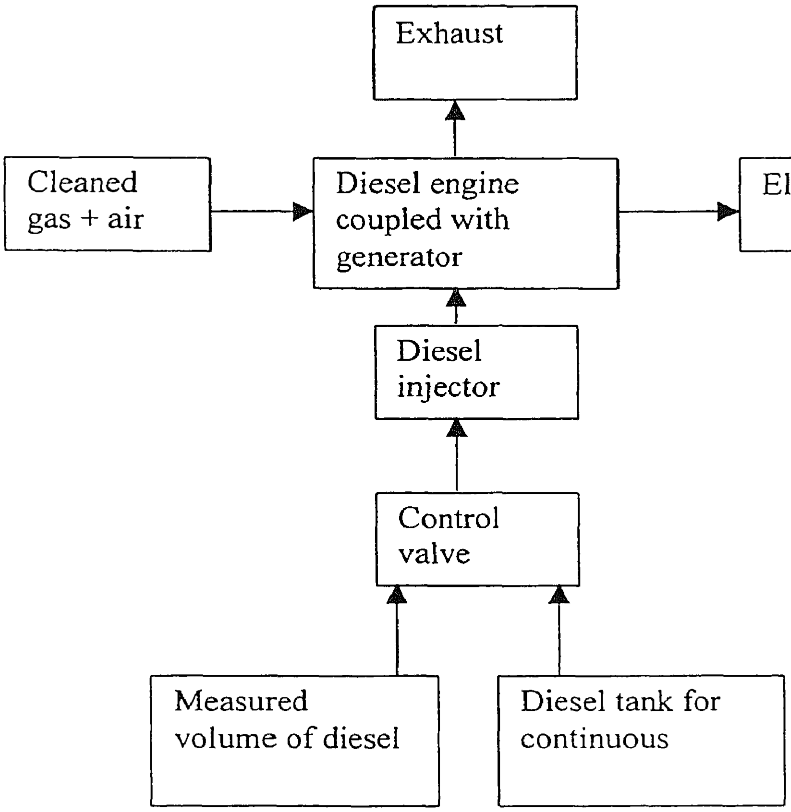
A flow chart is provided giving details of experimental set up of the gas calorific value measurement.

Gas Calorific value measurement



during diesel replacement and measurements. The diesel-injecting governor tuned to the optimum replacement by observing the sand and the level of frequency, voltage etc. A flow diagram is given with the details of diesel replacement.

Flow chart of diesel replacement measurement set up


Exhaust
Cleaned gas + air
Diesel engine coupled with generator
Electricity
Diesel injector
Control valve
Measured volume of diesel
Diesel tank for continuous

Numbers of readings were taken for the quantitative estimation of tar and dust, and gas calorific value and after analysis the results have been indicated in table 4.1 and 4.2. As can be observed from the table 4.1 the quantities of tar and dust were substantially on the higher side. The point to be noted here is that this is after all filtration of the gas. The calorific value of 1096 kCal/Nm^3 was at the stable flame condition. While these results were not encouraging it has to be kept in mind that these were almost the first generation gasifier. With the advent of technology and better understanding of the physics of the process, the technology of gasification too has improved substantially in recent years and in the present generation system most of the above problems have been taken care of.

Since there was no cable laid out from the engine to the Institute the engine had to be operated only with the load of the gasifier which was in the range of 7 kW. Considering this small load the diesel replacement measured was only 58% as

shown in table 4.3 and 4.4. This is again indicative of poor gas quality. The situation can however improve with a major overhaul of the engine since it was idle for very long time. The fluctuation in gas quality as explained earlier was also observed during dual fuel mode operations.

The photograph depicting various stages of the experiment are illustrated below. With the survey and detail experiment result available the next chapter gives the analysis of this study highlighting the major trends evolved.

Table 4.1. Tar and dust level measurements

Sl. No	Initial weight (W1) (g)	Final weight (W2) (g)	Tar + dust (W2-W1) (g)	Gas flow (liters)	Gas flow rate (lit/h)	Tar+dust (g/Nm^3)
1.	0.074	0.086	.012	32	384	0.434
2.	0.068	0.071	.003	11	388	0.471
3.	0.073	0.084	.011	27	324	0.316

Table 4.2. Experimental data on "Gas calorific value measurement"
Junker's Calorimeter experiment

Sl. No.	Water flow rate (ml/min)	Water temperature		Δt (°C)
		Inlet (°C)	Outlet (°C)	
1.	730	32.3	39 9	7 6
2.	730	32 4	40.1	7 7
3.	730	32.6	40.3	7.7

$$Gas\ \ flow\ \ rate\ \left(\frac{62}{10}\times 60\right) = 372\ \ lit\ /\ h$$

Gas temperature 49.4 °C

Calorific value 1096 Kcal/Nm^3

Table 4.3. Details of experiment on diesel replacement (Diesel mode)

Sl. No.	Diesel flow (ml)	Duration (minutes)	Flow rate (lit/h)
1.	430	4.33	5.73
2.	380	5.28	4.15
		Average	@=4.94 lit/h

Table 4.4. Dual fuel mode

Sl. No	Diesel flow (ml)	Duration (minutes)	Flow rate (lit/h)
1.	235	5.00	2.82
2.	240	5.00	2.88
		Average	2.85

Voltage = 440 Ampere = 20 Frequency = 49.5 Load: 7 kW

$$Diesel\ consumption\left(\frac{4.94-2.85}{4.94}\right)=\frac{2.09}{4.94}=42.3\%$$

Diesel replacement 57.7% $\simeq$ 58%

Preparation for testing

Plate 1: Preparation for Charcoal filling

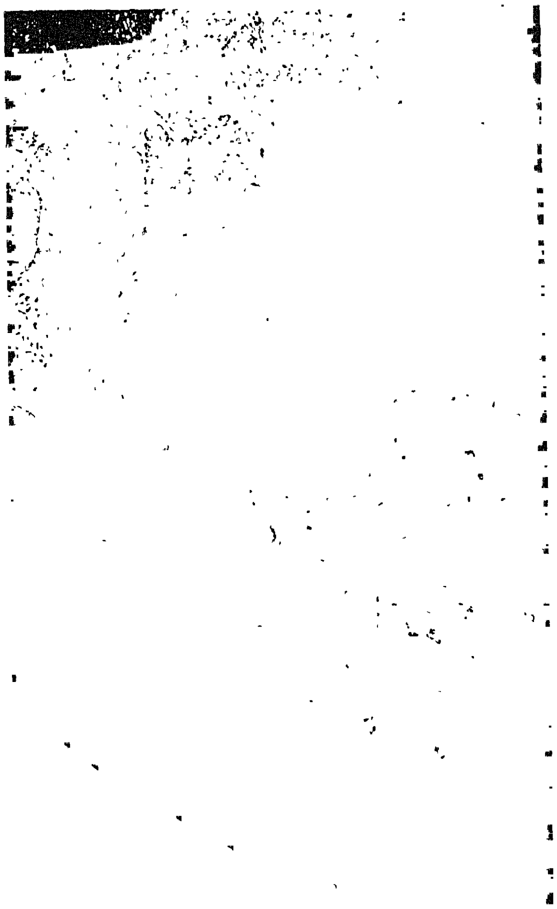


Plate 2: View after filling charcoal in the throat (combustion zone)

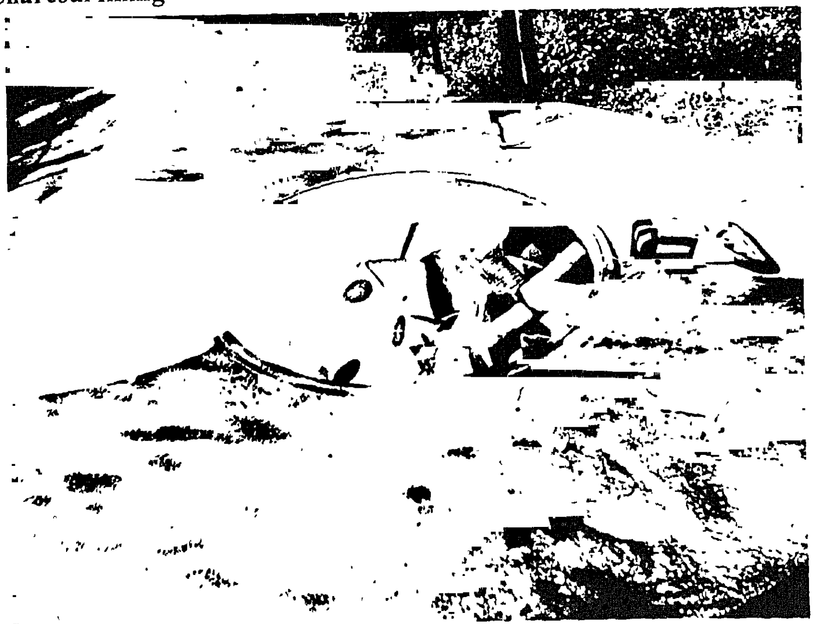


Plate 3: Hopper filled with wood chips

Observation of damages

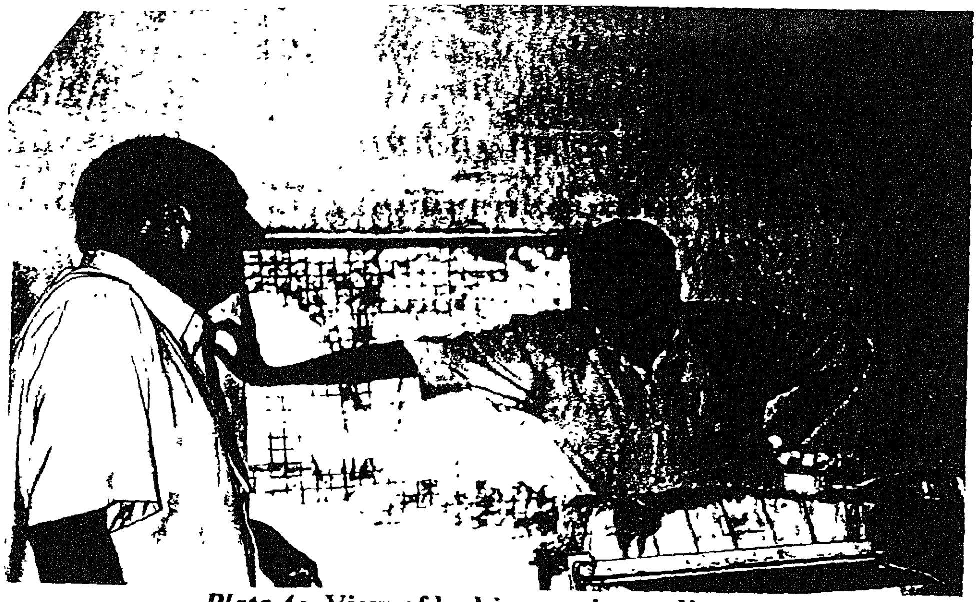


***Plate 4*: View of leaking engine radiator**

Plate 5: View of leaking oil pipe of the engine

Plate 6: Ignition of gasifier

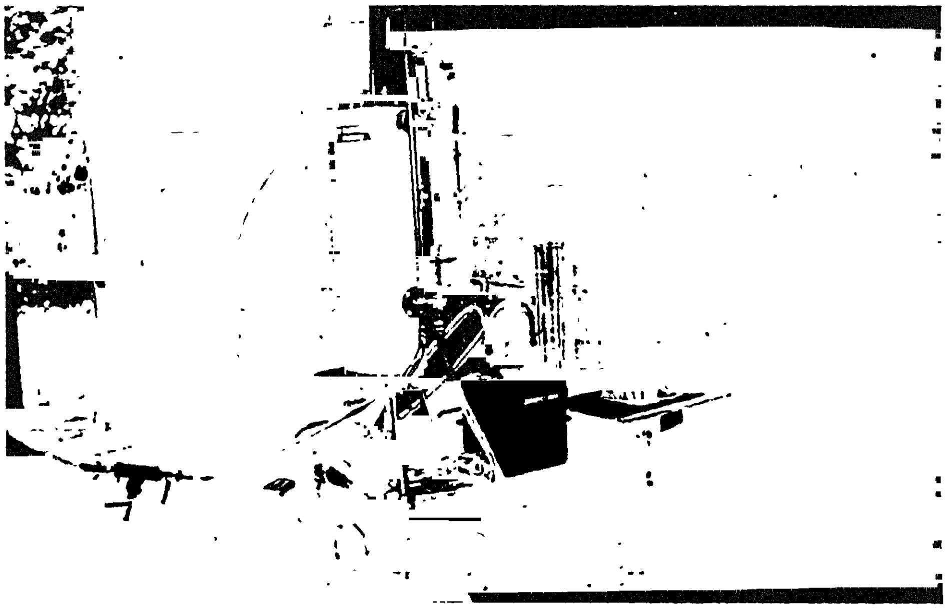


Plate 7: Junker's gas calorimeter set-up

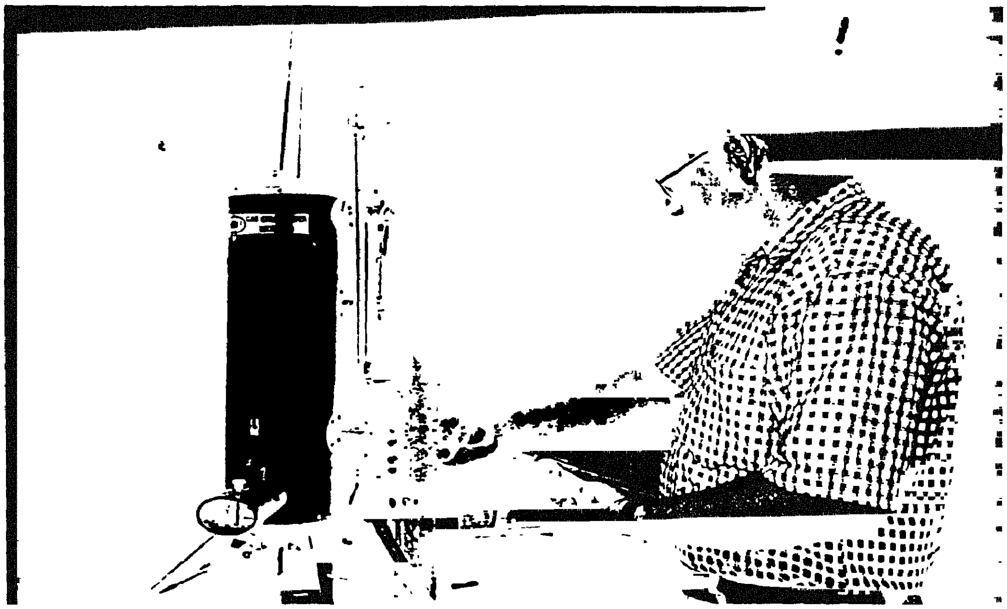


Plate 8: Measuring flow of water

Plate 9: Tar & dust sampling set up

5. Analysis of study results

With the outcome of the survey and results of the detail testing given in chapters 3 & 4 all the information from this study is assimilated. This bulk of information however needs careful analysis to identify the issues which actually governed the programme to its current status. This effort is required not only to identify the slips in the programme but also to highlight the achievements and innovative approaches which at times have set success stories. The present chapter attempts to identify these issues, analyses it to arrive at the conclusions for this study.

5.1 Major issues

Analysis of the current status of the gasifier unit and test results clearly bring out the following area which need immediate attention.

5.1.1 Need for the technology

For any technology to survive and improve the need for it must exists. As can be seen from the information on the 36 units surveyed except in a few cases, this aspect did not get proper attention by the implementators or planners. In many cases the units were installed at sites where there was very little need for the application (viz. power or water pumping) for which it was given. As a result there was no motivation of the user to utilize it. In some cases user already had at its disposal alternate ways to tackle his small requirements and was not keen to undertake the extra commitment which they have to make to use the unit installed at their premises, as seen in the case of “User No. 1 cluster Panchkula”. Similarly at chapter-3 in numerous other cases it has been clearly found out that lack of requirement was the major factor for non-utilization of the units.

5.1.2 User support and training

If we compare technology of gasification based power generation even at the present much developed level than the units surveyed; with diesel power generation or grid power it is definitely more cumbersome. While it is very

natural considering the short span of development in comparison with the later technologies, it calls for creation of proper user awareness about the same at installation site. User must be made known of the advantages as well as limitations of gasifiers and the precautions that they may need to take to make the full utilization. Coupled to that there should be the existence of adequate user support services and user training. While the manufacturers are generally entrusted with these responsibilities the implementing agency also must have adequate infrastructure for the same in terms of trained technicians, equipment etc. to handle requests from the user. As was found in the case of "user No. 1 cluster – Ambala" that a very successful and commendable installation after 2 years could not operate due to lack of user support. "Case 1 and 3 at Yamuna Nagar" also had similar situation where lack of support from the manufacturer led to non-utilization of the unit. A different case is "user No. 2 cluster – Panchkula" where there was total lack of user awareness to operate such unit in addition to other problems. There are ample cases where due to lack of user commitment when the operator was transferred the system could not be operated. Existence of a proper user support mechanism would have come handy to rescue these units from present state to a situation of proper utilization.

5.1.3 Subsidies

This is a major issue. Almost all the units have been given away with subsidy of varying nature from the central as well as the state government. while this was found necessary due to reasons as mentioned in chapter-1 during the initial stages of the programme, however, it also had its own fall out. This is evident from the survey. The subsidy actually takes away the commitment of the user to use the device because there is very little of the user's money at stake. The user does not realize the worth of the equipment because they have not made the bulk of the investment. This was realized both by MNES as well as the State Nodal Agency and in the subsequent years of the programme the subsidy component has been substantially reduced.

The survey also brings out the lacuna of the subsidy scheme. As can be seen that almost all units given under 100% subsidy are not in operation except for the only installation at Ambala which worked for 2 years since it

was financially viable. The worst scenario was at the Hissar Army Cantonment where 17 units have been installed. The concerned officials here admit that they acquired the unit because they were getting the genset completely free in the package. It is a clear case that user never wanted to operate the gasifiers and took the opportunity of misusing the incentives of the programme. In retrospect since the gasifiers are not in operation in this case, it indicates failure of the programme. However, it should be kept in mind that this failure is not a technology failure but a failure of management and implementation. The apathy is in all such failure it is the technology which is generally blamed while it is not the case. Hence this issue of subsidy should be very critically looked into in future.

.1.4 *Commercial viability and availability of fuel (biomass)*

In continuation of the previous subsection it is imperative that for any technology to be successful it has to be commercially viable. In the case of renewable energy technologies and especially gasification it was a difficult fact during early stages of the programme and hence the need was for subsidies. This situation has now changed to a very great extent. Systems offered by some of the groups now do have performance parameters which make them economically viable. This aspect however did not get much attention as found in the survey. Many of the units have actually stopped working because they were not economically viable for the user to operate them e.g.; case 5 of Yamuna Nagar, case 1 of Sirsa etc.

For a system to be economically viable the cost of fuel (biomass) plays a major role. It is necessary to therefore find out and calculate the viability before the installation is made. While there are many variables which can effect the calculations however considering the major factors a sample calculation is given in Annexure - 2. The Figure 5.1 also gives a quick estimation of the viable fuel (fire wood) cost at different plant load factors. As can be seen the higher utilization (PLF) can also absorb higher fuel cost but the limit is Rs. 1.40/kg of biomass (even at a high PLF of 0.7) where the cost of generation equals out to diesel mode.

Again the important point is that going by the lower cost and availability of biomass alone should not be the only criteria either. It has been found in

the numerous cases that (case 1 & 2, Panchkula; case 1 & 2, Jind; case 1,3, & 4, Yamuna Nagar etc.) while plenty of wood and also labour is available the units did not succeed to run due to other reasons mentioned above. This basically indicates that a comprehensive evaluation of various factors are required to ascertain the suitability of a particular site for this technology and this is actually the responsibility of the implementing agency.

5.1.5 *Technology*

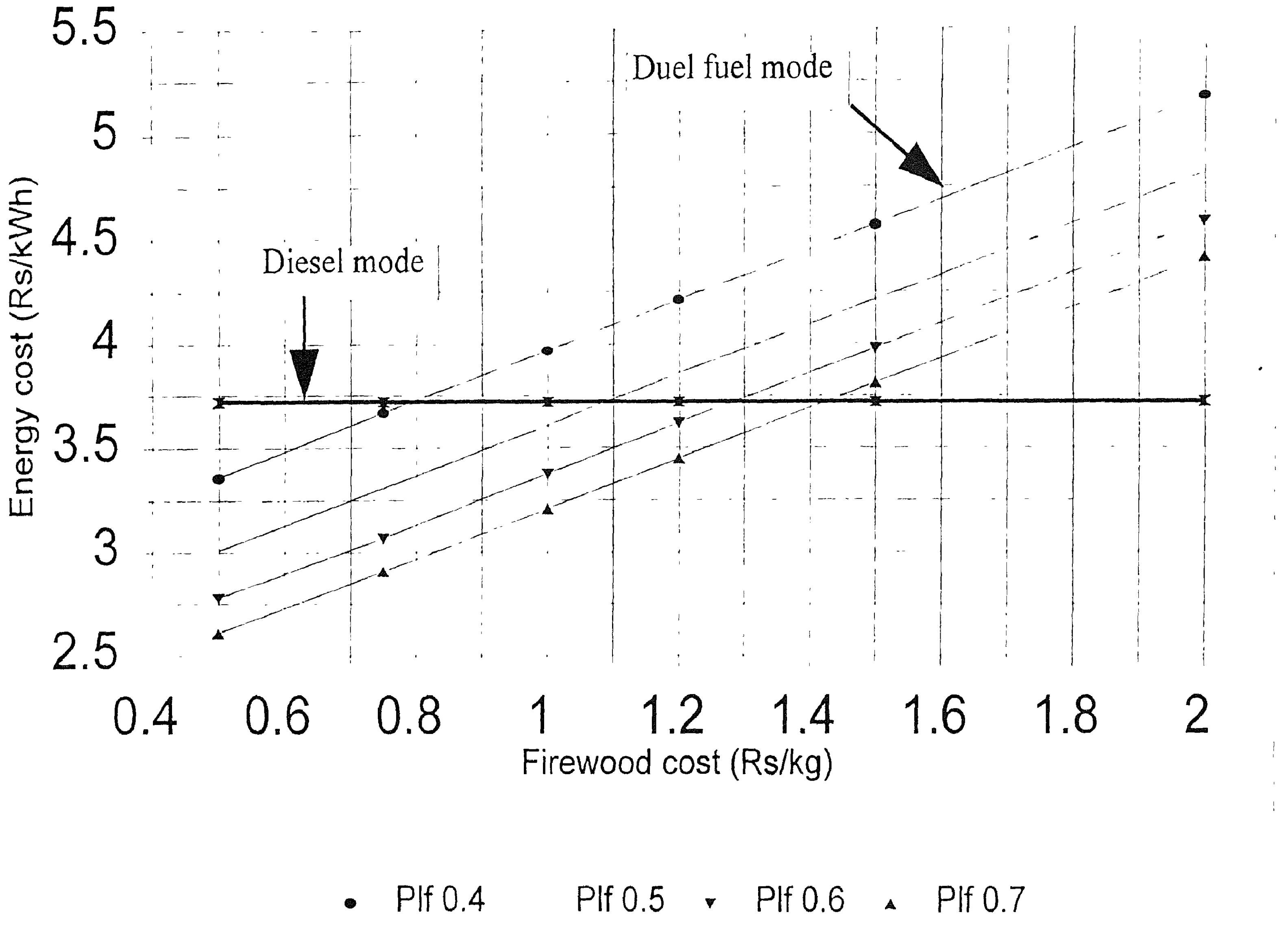
Against the contention the study did not indicate any system non-usage due to inadequacy of the technology. This should not be mis-understood that the technology had matured at that time. This only indicates that other factors as listed above had greater role to play in non utilization of the gasifiers rather than the technology. In fact in some cases (case 1 & 2 at Jind) the cumbersome way a gasifier needs to be operated in terms of wood preparation etc. was the minor discouraging factor. This along with other factors induced the user to abandon the gasifier and switch to full diesel mode operation of D.G. set. Just the opposite case is of Oberoi Furniture House, Ambala, where the user operated the gasifier till he could because it was commercially viable for him. What it indicates is that while it is extremely essential to improve the performance and user friendliness of a technology, at times, when the technology has matured to a certain extent, it is the other factors which start playing deciding role about the success of the technology. Some of the present generation gasifiers have much better performance standards than what has been observed as explained in chapter-4. However, this study brings out that success of even this improved technology will greatly depend on proper consideration of the other important aspect as discussed earlier.

5.2 Conclusions

From the above discussion it can be summarized that:

1. Need and utility of the gasification technology should be the primary criteria in deciding the site for installation. Capacity estimation to meet the user requirement should be carefully evaluated.
2. The system must be commercially viable so that the user is motivated to use the unit. Necessary studies should be conducted and realistic calculations to be made to ascertained this aspect.
3. Systems should be tried at a few places before large dissemination.
4. Strong user support/after sales service network involving manufacturer, trained personnel at the implementing agency must be created before embarking on such a programme.
5. Subsidies should be reduced and eventually eliminated to avoid misuse of the scheme and to identify genuine users who would like to go for the gasification technology.
6. Technology needs to be updated to improve the performances and user friendliness of the gasifier systems. It would be very interesting to develop a mechanism to get a continued user feed back and to communicate the same to the system manufacturers and technology developers across the country.

FIGURE 5.1: Electric power generation cost



6. Recommendations for future work

The conclusions of this study as discussed in the previous chapter also brings to light certain areas which calls for serious attention as logical extension of this activity. In the present chapter therefore brief discussion of these seem justified with the holistic view to make the gasifier technology programme more popular and successful in times to come.

6.1 Biomass gasifier applications

Considering the biomass gasifiers running on woody biomass there are some basic problem. Firstly it is the availability of the biomass (wood). Since it is scarce in most parts of the country it is also costly. This in turn makes the utilization of the same for power generation costly and less competitive as compared to the existing conventional technologies. Therefore, as debated in the previous chapter availability of cheap woody biomass coupled with established need of the user is of primary importance for wood gasification based power generation. This criterion obviously reduces its wider dissemination. On the other hand traditionally there are many industries/commercial activities where wood is perennially used. Few among them are: large cooking done at Gurudwaras, jaggergy making industries (KHANDSARI), for supply of hot water in medium sized hotels and motel especially in small cities etc. In addition there are many industries which use fuel oil fired boilers, thermopac etc. A simple calculation shows that coupling these units to gasifier and thereby saving wood (i.e. conserving wood) or saving fuel oil even, makes much better economic sense. It is therefore recommended that the thermal applications of gasifier should be given more thrust in future. However, at the same time, it is appropriate to go ahead with power generation wherever it is economically viable.

6.2 Alternate fuel for gasifiers

The previous section also points out the necessity to develop gasifiers based on agro-residues which are truly renewable. Many of these do not find proper utilization and hence are very cheap. Especially in the case of Haryana, this

may mean residues like mustard stalks, rice husk, rice straw having more potential. While rice husk gasifiers are commercially available they are marred with many operational problems. These include formation of air channels leading to localized and non-uniform very high temperature combustion. This phenomena gives rise to fluctuating gas quality as well as generation of clinkers which choke the gasifiers. Frequent formation of bridging which reduces gas quality increasing the tar content. In general in rice husk gasifiers the tar generation is higher, and due to the above instabilities in the present devices, most of the time uniform high temperature gasification is not possible. Therefore, the chances of thermal cracking of tar being less the gas is generally dirty. This in turn puts in lot of maintenance load on the tar filtering subsystems. Another problem is removal of char. None of the commercial gasifiers come with proper char removal mechanisms, leaving this aspect on user's ingenuity. This is because rice husk by nature has more than 20% of ash and also most of the gasifiers work at lower gasification efficiencies. The result therefore is char generation which is 30% by weight or 40% by volume of rice husk consumed by the gasifier. This is a large quantity and therefore proper char removal mechanism should be the integral part of the gasifiers. Thus in totality control of gasifier in itself, keeping the filtering units in proper operational condition and managing char removal puts in tremendous operational load on the user. This makes the units very cumbersome. In some designs there is also the need for preheating, and controlling the rice husk flow manually. This only adds to the operational problems and makes the user acceptance of these systems low. A handful of these units which however, have been sold are again driven by indirect financial gains due to inbuilt subsidies and income tax benefits from accelerated depreciations.

These gasifiers also cannot accept other residues as listed above. It is therefore extremely necessary to have concentrated developmental efforts to achieve fine biomass gasifiers which can handle various kinds of agro-residues. The design also must overcome all the drawbacks of the existing system as mentioned above.

Therefore, as an end note it can be summarized that the biomass gasification programme per se is very exciting one. The present situation however, demands that thermal applications of biomass gasifiers be given more thrust. Some of the other important aspects have already been summarized in the conclusions of Chapter 5. It is also recommended to give thrust to fine biomass gasifier developmental efforts to make this programme more popular.

Annexure - 1

TATA ENERGY RESEARCH INSTITUTE

India Habitat Centre, Lodhi Road, New Delhi

Questionnaire
for
Performance evaluation of biomass gasifiers for Electrical/Water pumping applications

I. User info

1] Name of Institution/Industry :

2] Main activity/product/process:

3] Address for correspondence :

4] Name of contact person :
Designation : Phone: Fax·

II. Gasifier info

1] Year of commissioning . :

2] Make, Model, Sr. No. :

3] Rated capacity . kWe / Nm^3/hr. / HP (*for water pumping*)

4] Starting system :
Type : Elect. Blower / Hand blower / Other method (*specify*)
Power : kW / HP

5] Mention the instruments provided & their purpose :

6] Are these instruments functioning, If not kindly state which instrument is not functioning & why :

7] Any action taken to repair it :

8] Has manufacturer responded immediately :

9] Time needed in practice to start the gasifier
    from torching to flaring :
    from flaring to engine operation :

III Application mode [*delete whichever not applicable*]

Electrical

1] Engine make, rating(Bhp), rpm :

2] Alternator rating(kVA, Amps, Hz) :

3] Load availability(kW) :

Water Pumping

1] Engine make, rating(Bhp), rpm :

2] Water head availability : seasonal / 12 months

3] Height of the head :

IV Usage

1] Is gasifier engine in operation:

2] Since commissioning
  2a] how many hours did the engine operate in full diesel mode :
  2b] how many hours did the engine operate in dual-fuel mode

3] What was the amount of diesel replacement achieved :

4] Presently how many hours per day it is operated & why :

5] What was the longest non-stop run of the unit :

6] Is it operated with recommended size of charcoal and wood piece :

7] Did the maintenance schedule for gasifier & engine followed properly :

8] Duration of warrantiy and did manufacturer provied services during this period :

9] Any problems encountered in operating the gasifier If yes, kindly explain briefly the nature of the problems : yes / no

9a] Is it an operational/mechanical/ hardware problem [*Explain*] :

9b] How many hours of gasifier operation took place before the 1st. occurrence of problem :

10] Did manufacturer respond quickly to service call :

11] Has manufacturer given adequate training to operate the gasifier and what was the duration of the traning[*explain briefly*] :

12] Has manufacturer given adequate training to operate the engine in both (*full diesel & dual-fuel mode*) [*explain briefly*] :

13] Till date any break-down happened in gasifier or engine [*explain briefly the nature of the problem & how it occurred*] :

14] What action was taken to rectify it [*kindly explain*] :

15] Manpower required to operate the gasifier-engine setup [*Kindly indicate how many persons are required under the following heads* {*give numbers/strike off which is irrelevant*}] :

	Shift-1	Shift-2	Shift-3
Supervisor			
Operator			
Electrician			
Engine operator			
Labors			

16] What is your opinion about the user-friendliness of the setup [*was it difficult to get/motivate people to operate the unit properly, In your opinion what are the major difficulties in operating the unit*] [kindly explain] :

17] Do the same group of operators operate the system all the time, if not kindly state the reason: :

18] In your opinion what is the actual operating cost of the unit and how :

V Biomass

1] What is the type of biomass used for operating the gasifier :
Wood
Agro residues
Cotton stalks
Tuver stalks
Briquettes
Others [explain]

2] Any problem faced in acquiring biomass :
2a] because of seasonal variation
2b] or because of any other reason

3] Quantum of biomass available [tonnes/month] :

4] Price of Biomass variation : Maximum Mininum

5] Was sizing [*cutting to size*] biomass a problem :

6] Method of sizing the biomass : through mechanical cutter / Manual labor

7] Any problems faced in sizing the biomass, *if yes, kindly state the problem* :

8] What is the biomass and diesel consumption (per hour basis) :

9] What was the trasportation cost and and type of transportation used :

10] Extent of biomass collection area :

VI Economic assessment

1] Cost of the system
   Gasifier :
   Diesel engine :
   Other equipment :
2] Amount of subsidy received :
3] Explain the benefits derived by installing the unit :
   3a] Financial
   3b] Operational
   3c] Social
   3d] Environmental

VI General

1] In your opinion what are the main problems with this gasifier-engine unit :

2] Would you give some suggestion to improve the existing setup :
3] Was there any prior acquaintance to this technology at the user□s end :

We thank you for your valuable time spent on giving us the above feed back and hope to receive similar cooperation from you, if required, in times to come.

Date:

Signature :
Name :
Designation :
Address :

Investigator's comments [*if applicable*]

Signature :
Name :
Designation :
Date :

For on-site use by teri investigator

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INSPECTION FORM
for
Performance evaluation of biomass gasifiers for Electrical/Water pumping applications

I. User information

1] Name of Institution/Industry :

2] Main activity/product/process :

3] Address for correspondence :

4] Name of contact person :
Designation : Phone: Fax:

II. Gasifier information

1] Name of gasifier supplier and address :

2] Year of commissioning :

3] Make, Model, Sr. No. :

4] Rated capacity : kWe / Nm^3/hr. / HP (*for water pumping*)

5] Starting system :
Type : Elect. Blower / Hand blower / Other method (*specify*)
Power : kW / HP

6] Mention the instruments provided with the unit and their purpose :

7] Are these instruments functioning. If :
not kindly state which instrument is
not functioning & why

8] Is gasifier-engine/gasifier-pumpset :
unit intact

9] The physical condition of the unit and
its components
- 9a] Check for material failure
- 9b] Internal breakage/degradation
- 9c] Cracks due to thermal stresses
- 9d] Look for the traces of tar deposition
- 9e] Look for rusting and holes etc.

10] What was the frequency of breakdown :
before permanent closer

11] What was the amount of diesel replaced :
as per the records

12] Consistency and performance of the :
gasifier in terms of
- 12a] Quality & quantity of the gas output
- 12b] Stability of the flame
- 12c] Leakages in the piping
- 12d] Diesel replacement
- 12e] Engine noise etc.

13] Time required to start the gasifier :
- 13a] From torching to flaring
- 13b] From flaring to engine operation

14] Are there any blockages in the air nozzle :

15] Method of fuel feeding : Manual / Automated
(explain)

16] Is hopper capacity sufficient for two hours :
operation at full rating

17] How frequently gasifier needs feeding :

18] Degree of automation provided :

19] Where their any incidence of backfires, :
did it became a major concern explain

20] Check the list of equipments :
Gsifier
Cooling and cleaning system
Cutter
Engine etc.

21] What are the gas cleaning equipment and thier present status :

22] What was the maintenance schedule for the gasifier-engine unit :

23] Any other observations / comments :

24] Check the purchase order to see wheather the equipment presently existing is the same what has been ordered :

Name :
Designation :
Signature :
Date :
Place :

Annexure - 2

Generation cost comparison and pay back analysis for gasifier-DG Set combine vis-à-vis 100% Diesel power generation and Grid Power

SYSTEM DETAILS AND ASSUMPTIONS

This case study is for a 100kWe biomass gasifier connected to a DG set of 125 KVA rating. It is further assumed that the peak load is 80 kW and the duty cycle is 24 hrs per day for 365 days per year.

Diesel requirement for power generation in dual-fuel mode varies from 100 to 90 cc/kWh, alongwith the corresponding biomass requirement from 0.9 to 1.0 kg/kWh. On a conservative side both the diesel and biomass requirement for the present calculations is taken on the higher end as 100 cc of diesel & 1.0 kg of biomass per kWh.

SFC for 100% diesel mode is taken as 0.3 lit/kWh
Cost of Diesel = Rs. 10.0 / litre

COMPARISON WITH 100% DIESEL POWER GENERATION [*PLF = 0.8, biomass Rs. 1000/ton*]

Total units generated per annum = No. of units generated per hour x 24 hours x 365 days x PLF
= 80 x 24 x 365 x 0.8 = 560640 units

Fuel cost of power generation

In dual fuel mode = Rs. 2.0 / kWh
In 100% diesel mode = Rs. 3.0 /kWh

Cost of manpower (per annum)

I] For gasifier DG set combine in dual fuel mode

For per shift of 8 hours

Engine & gasifier operator = No. of operator x Salary per month x 12 months
= 1 x 3600 x 12 = 43200

Helper for gasifier = No. of helper x Salary per month x 12 months
= 1 x 2400 x 12 = 28800

Total manpower expenses = Rs 720000

For the total 3 shifts of operation Rs. 720000 x 3 = Rs. 216000

Cost of manpower per kWh = Rs. 216000 / 560640 = **38 paise**

II] For 100% diesel mode of DG set

For per shift of 8 hours

Engine operator = No. of operator x Salary per month x 12 months
= 1 x 3600 x 12 = 43200

Total manpower expenses = Rs 43200

For the total 3 shifts of operation Rs. 43200 x 3 = Rs. 129600

Cost of manpower per kWh = Rs. 129600 / 560640 = **23 paise**

Likely cost of engine consumable per kWh [approx. 8% of the diesel cost]

For dual-fuel mode = 16 paise
For 100% diesel mode = 24 paise

Cost on miscellaneous and contingencies

Taken as 10% of the sub total for the respective case

Sub Total
For dual fuel mode [2.00+0.38+0.16] = Rs. 2.54
For 100% diesel mode [3.00+0.23+0.24] = Rs. 3.47

Hence, cost on miscellaneous & contingencies

For dual fuel mode = 25 paise
For 100% diesel mode = 35 paise

Likely cost of power generation

In Dual fuel mode [Rs. 2.54 + 0.25] = **Rs. 2.79 / kWh**

In 100% diesel mode [Rs. 3.47 + 0.35] = **Rs. 3.82 / kWh**

Net savings

In dual fuel mode as compared to 100% diesel generation = Rs. 3.82 – 2.79
= **Rs. 1.03 / kWh**

COMPARISON WITH GRID POWER FROM SEB'S [*PLF = 0.8, biomass Rs. 1000/ton*]

Considering this connection to be an HT connection as per the norms of many SEBs e.g., Karnataka State Electricity Board the projections are as follows:

[1]Initial deposit = Rs. 2190 /KVA

Sanctioned power = 125 KVA

---

[1] The deposit money is actually an expenditure as it is never returned back unless the power connection is surrendered.

Maximum Demand = 100 KVA

Power Factor = 0.80

No. of units delivered on 24 hrs per day = 100 x 0.8 x 24 x 365 x 0.8
Basis, for 365 days [1 year] = 560640 units

Initial deposit cost [apportioned over the units generated] @ 18% = Rs. 0.07

Cost of Equipment's [Transformer & panels] = Rs. 5.0 Lacks

Cost of funds / unit @ 18% = (500000 x 0.18) / 560640
= Rs. 0.16 / unit

Fixed demand charges payable @ Rs. 130 / billed KVA per month or 75% of sanctioned KVA, whichever more = (130 x 93.75 x 12) / 560640
= Rs. 0.26 / unit

Likely current SEB tariff = Rs. 3.50 / unit

SEB tax per unit = Rs. 0.20

Total Power tariff = Rs. 0.07 + 0.16 + 0.26 + 3.50 + 0.20
≅ **Rs. 4.20 / kWh**

*To arrive at the above tariff as can be seen that a 24 hrs duty cycle and PLF of 0.8 has been assumed for the industry, while if it is lower the effective tariff can well be in the range of **Rs. 5.00 + / kWh.***

Net savings

In dual fuel mode as compared to grid tariff = Rs. 4.20 – 2.79
= **Rs. 1. 41 / kWh**

PAY BACK OF CAPITAL COST

I For Gasifier-DG set combine

Equipment cost [Gasifier with all accessories however without PLC controls] = Rs. 770000

Cost of DG set = Rs 550000

Total investment = Rs. 1320000

Less MNES subsidy = Rs. 264000 (-)

Net investment = **Rs. 1056000**

II For Gasifier alone

Equipment cost [Gasifier with all accessories however without PLC controls] = Rs. 770000

Less MNES subsidy = Rs. 264000 (-)

Net investment = **Rs. 506000**

Comparison with 100% diesel generation

I For Gasifier-DG set combine

Interest on investment @ 18% = Rs.190080

Yearly savings on 560640 units = Rs. 1.03 x 560640 = Rs. 577459

Accelerated depreciation available On net investment & hence IT Savings [Rs. 1056000 x 35%] = Rs. 370000

Annual savings

FIRST year [(Rs.577459 + 370000) – 190080] = **Rs. 757379**
SECOND year [Rs. 577459 – 190080] = **Rs. 387379**

II For Gasifier alone

Interest on investment @ 18% = Rs. 91080

Yearly savings on 560640 units = Rs. 1.03 x 560640 = Rs. 577459

Accelerated depreciation available On net investment & hence IT Savings [Rs. 506000 x 35%] = Rs. 177100

Annual savings

FIRST year [(Rs.577459 + 177100) – 91080] = **Rs. 663479**

The pay back thus works to be little less than two years, for the investment of gasifier with DG set vis-à-vis less than one year for gasifier alone. However it is to be noted that the calculations are conservative without taking into account the escalation in diesel prices which will make the picture even more attractive.

Comparison with Grid Power

I For Gasifier-DG set combine

Interest on investment @ 18% = Rs.190080

Yearly savings in lieu of buying 560640 units = Rs. 1.41 x 560640
= Rs. 790502

Accelerated depreciation available On net investment & hence IT Savings [Rs. 1056000 x 35%] = Rs. 370000

Annual savings

FIRST year [(Rs.790502 + 370000) – 190080] = **Rs. 970422**

II For Gasifier alone

Interest on investment @ 18% = Rs. 91080

Yearly savings in lieu of buying 560640 units = Rs. 1.41 x 560640
= Rs. 790502

Accelerated depreciation available On net investment & hence IT Savings [Rs. 506000 x 35%] = Rs. 177100

Annual savings

FIRST year [(Rs.790502 + 177100) – 91080] = **Rs. 876522**

The pay back is thus little above one year for the investment of gasifier with DG set and less than one year for the investment of gasifier alone. The above calculation also does not take into account the effect of escalation in grid tariff as well as the effect on production, due to non-reliable & poor quality of the grid. Consideration of these factors can make the pay back even more attractive.